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Part 1

TECHNOLOGY TRANSFER TO CHINA

VOLUME II: WORKING PAPERS

Part I

1. The Role of Technology Transfer for China's Economic Future; Rock Creek Research, Inc.
2. China's Evolving Computer Industry: The Role of Foreign Technology Transfers; Denis Fred Simon.
3. Satellite Telecommunications Technology Transfer to China; China Business Development Group.
4. Railroads of the People's Republic of China; The American Society of Mechanical Engineers.

Part II

5. The Transfer of Western Managerial Knowledge to China; William A. Fischer.
6. National Security Risks of Dual-Use Transfers to China; Science Applications International Corporation.
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8. China's Foreign Policy, Beijing's Military Modernization and American Policy Alternatives; Thomas W. Robinson.
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November, 1987

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The Role of Technology Transfer for China's Economic Future

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THE ROLE OF TECHNOLOGY TRANSFER FOR CHINA'S ECONOMIC FUTURE

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CHAPTER ONE

EXECUTIVE SUMMARY

1.1 Successful technology transfer to China will accelerate domestic growth well beyond the official targets for the year 2000 and make manufactured exports, especially consumer electronics, competitive on a significant scale.

China's economy has changed dramatically in the decade since Mao Zedong's death in 1976. Economic institutions have been reformed fundamentally, the pace of domestic economic growth has accelerated rapidly, and China has undertaken full-scale engagement in international economic relations. This report estimates where China's new economic course might lead by the end of the twentieth century, both domestically and internationally, and how technology transfer will affect this course. The role of technology transfer in China's economic development is examined for three specific industries, clothing, consumer electronics, and motor vehicles, each representing a different level of difficulty in technological absorption and export potential.

The major conclusion of this report is that growth of national product will be significantly more rapid than envisioned in official targets for the year 2000. Technology transfer has played a valuable role in China's growth and will greatly increase in importance in the future, especially for more technologically advanced industries such as consumer electronics and motor vehicles. A further conclusion is that China will actively acquire technologies which allow for increases in product quality, rather than those technologies which are primarily labor-saving.

1.2 A review of computer projections of China's economy done at the World Bank, Stanford University, and Rock Creek Research shows that subjective judgments by the modelers are as important as formal modeling relationships. Both World Bank and Stanford projections tie output projections to official Chinese targets, while Rock Creek Research projections incorporate information from China's most recent reform and growth experiences.

The projections reviewed represent a range of theory, sectoral detail, practical specification and base data. In each case, the results reflect much more the personal judgments of the modelers and much less the technical specifications of the actual computer models, because discretionary elements in the modeling allow adjustment of results until they fall in what the modeler considers to be a reasonable range.

As a guide to China's future, each projection has its special merit. If one feels that China ultimately will have difficulty escaping the pattern of growth characteristic of the Maoist period, before the current program of reforms, then the Stanford University Projections (by Professor Lawrence

Lau) form a good basis for predictions. If one believes that official long-term targets contain the most complete information on China's true capabilities, then the World Bank results offer a wealth of detail made to fit exactly into the official goals. If one believes that official targets are conservative and that recent economic trends have revealed a potential for growth unrealized before 1983, then the Rock Creek Research projections provide rough orders of magnitude for the shape of China's economy in the year 2000. Table 1-1, below, provides a quick comparison of the growth rates for the three projections. For the Rock Creek Research results, two scenarios, a high and a low, are presented.

Table 1-1
Comparison of Real GDP Growth Projections, 1981-2000

	Agriculture	Industry	Other	Total
World Bank Quadruple	4.9	7.[illegible]	7.6	6.6
L. Lau High Scenario	3.4	7.9	6.7	6.7
Rock Creek Research Low	5.7	7.7	9.3	7.8
Rock Creek Research High	5.7	9.3	9.8	8.7

SOURCES: World Bank, **China, Long-Term Prospects**, 1985, L. Lau, **A Model of the Chinese Economy**, unpublished, 1985, and Chapter 9 in this report.

The high Rock Creek Research projections are justified by China's record of productivity growth in the early 1980s, based on data which were not available when the World Bank and Lau projections were completed. International trade projections show Lau's estimates to be lower than the others, with exports as a share of GDP falling from 11 percent in 1981 to roughly 6 percent in the year 2000. The World Bank and Rock Creek Research Low scenario maintain the ratio at roughly 11-12 percent. For a fuller discussion of these and other trends, see Chapter 2 and Chapter 9.

1.3 For China, low-technology-gap industries such as clothing are already competitive in world markets and will increasingly displace South Korean and Japanese exports to the U.S. Very low labor productivity in the industry does not reflect a gap in quality-determining technologies but rather a gap in labor-saving technologies, which is irrelevant at China's current level of development because of the extremely low wages prevalent.

China's export potential in the clothing sector, barring non-technical factors such as protectionism, is excellent. With or without major imports of technology, China will prove to be a very important exporter of low-cost, low-, medium-, and high-grade apparel to OECD markets. Having already achieved import penetration, continued exports in the short-term are assured, and intermediate-term export growth will be strong.

Very low worker productivity in the apparel industry is more than offset by low labor costs, which make Chinese garments very price competitive in world markets. China's low labor productivity does not reflect a technology gap in terms of product quality, but is rather a technical accommodation to plentiful cheap labor supplies. In terms of its importance for product quality and export competitiveness, then, production technology and the size of a technology "gap" are not as critical for the clothing industry as for the consumer electronics and motor vehicles industries.

1.4 The success or failure of technology transfer to China will be most obvious in industries such as consumer electronics, in which China has a long record of indigenous production but poor success in establishing large-scale commercial output of high-quality goods. The prospects for China's consumer electronics sector, and in particular exports, are very good in the intermediate and long-run, and could be significant in the near future if foreign exchange is available for the importation of modern production capacity on a significant scale.

China began consumer electronics production with vacuum tubes, introduced transistor and integrated circuit technology somewhat in pace with the rest of the world, and has become one of the world's largest producers of the industry's most representative products, such as radios. However, China's productivity and technical levels in consumer electronics vary widely from facility to facility and are backward in a significant proportion of all enterprises. Large-scale production has generally been unable to replicate the quality prototypes produced by small-scale shops and research divisions.

The competitive position of China's consumer electronic exports in the short-run and even the intermediate-run will depend a great deal on the degree to which production technology is imported, but long-run competitiveness is assured by the existence of a well-established industry with indigenous technical levels capable of eventual modernization at a rate considerably faster than the rate of technical change at the frontier of world consumer electronics.

1.5 In spite of a long history of domestic motor vehicle production in China, the industry's technology is little improved from its 1930s-level origins, and many observers see no chance for China to become a motor vehicle exporter by the end of the century. Nevertheless, the size of the domestic market and the clear demand for large numbers of high quality vehicles could accelerate the industry's modernization in comparison to its development in South Korea.

Like Japan in the 1940s and 1950s, China is relying on domestic market protectionism and technology transfer to overcome its backward technology and eventually to enter a mature world market. Korea, in contrast, did not have an indigenous base and was forced by licensing agreements to constrict its output and exports in order to obtain any technology at all at a much later date in its overall economic development. The potential speed of the industry's development in China depends largely on China's ability to obtain and absorb foreign technology, but thus far China has been disappointed in the amount of technology foreign firms have been willing to provide.

According to current plan projections, import substitution from joint venture vehicle production is to play a major role in upgrading, expanding, and modernizing China's motor vehicle production, especially for passenger vehicles and four-wheel trucks. However, despite the clear official desire to export vehicles, Western industry specialists doubt that significant exports will be possible for some time. In many cases the Chinese have been frustrated by the refusal of foreign companies to provide technology for models modern enough to compete internationally.

1.6 While case studies of individual industries provide a general background for assessing China's technology gap, more quantitative analysis shows that for many detailed commodity groupings, especially in apparel, China already commands a significant share of the U.S. market for imports from Japan, South Korea, and China combined. The same analysis maps out the detailed commodity groupings successfully exported by Japan and Korea and confirms that China's future export growth will probably first be realized in consumer electronics and then motor vehicles.

In order to supplement the qualitative analysis of the differences between China's technology levels and those of its competitors, Chapter 6, below, ranks exports from China, South Korea, and Japan to the U.S. according to market shares to obtain an ordering of detailed commodity groupings by their hypothetical level of technical sophistication. The analysis confirms that China already has a significant share of the U.S. market for sleepwear and other less technically demanding clothing. In consumer electronics, however, China in 1985 could not compete with Korea, much less with Japan. By ranking commodities according to technical sophistication and by putting China at the bottom of the ladder, the analysis illustrates the path of expansion China is likely to follow.

The methodology assumes that to the degree that a commodity is exported by Japan but not South Korea or China, it is technologically advanced and difficult to produce. Similarly, a commodity is technologically unsophisticated to the degree that China controls the largest market share of exports to the United States. This methodology is based on the economic theory that new products or enhanced quality standards require the highly skilled labor or extremely sophisticated capital-intensive production methods available in Japan. Conversely, older products with traditional quality standards can be produced by low-skilled and capital-poor methods characteristic of China.

In addition to depending on these assumptions about technology's evolution and just as for the case studies reviewed above, the analysis makes comparisons among densely populated East Asian market economies rather than comparisons to centrally planned East European economies. This perspective is significant in that it emphasizes that China is moving away from Soviet bloc economic institutions and policies towards economic systems more typical of other East Asian nations.

1.7 Many characteristics of China's society and economy which are not specifically technical in nature nevertheless contribute a great deal to the prospects for successful technology transfer and rapid productivity growth. Compared to other East Asian economies which have already advanced far beyond China's development level in numerous dimensions, China's social, cultural, managerial, educational and other endowments are quite poor. But compared with most other poor countries in the world, especially those in Africa, South Asia and even Latin America, prospects for technology transfer to China are enhanced by a wide range of conditions.

China's productivity and competitiveness are affected by numerous non-technological factors. Interpreted broadly, these factors include China's labor force, capital stock, and raw materials, including energy supplies. They also include the newly-emerging economic environment and the quality of leadership at all levels. In each of these categories, China has a strong resource base which contributes significantly to prospects for productivity growth. For example, China's labor force is literate, well disciplined, accustomed to working in large organizations, comfortable with technical tasks, and generally in good health. From a technical viewpoint China's capital stock is of poor quality, but it is in place nevertheless; in many cases, it will be easier to renovate and upgrade existing plant and equipment than to build from scratch. Similarly, China's high national savings and capital accumulation rate is a national asset, especially when compared with other developing countries.

China's economic environment is perhaps more important than its factor endowment. This environment includes emerging economic and legal systems, the overall size of the Chinese market, income levels, the distribution of income, and the existing information system. Under Deng Xiaoping's reforms, many of these dimensions of China's economic environment offer potential for productivity gains throughout the economy. Productivity and competitive capacity are further enhanced by the increase in choices and substitutes available to various economic actors, including producers, investors, and consumers. Direct horizontal linkages among economic entities have been encouraged under the reforms, and the freedom to productively match basic factors with raw materials is stronger in China today than even a few years ago.

There are, however, reasons for caution when considering China's technology transfer prospects. In particular, to varying degrees, China suffers from a poor existing productivity base, some potential for financial difficulties related to technology transfer, labor force productivity problems inherited from the Maoist period, and the incomplete evolution of the new market-oriented system. In general, these factors are not strong enough to outweigh the large contribution made to technology transfer by China's generous non-technical endowment, but in individual instances, any or all of them could become critically relevant.

1.8 Reviewing China's overall technology gap with Japan and the West, backwardness affecting product quality is the most crucial, while low technical levels resulting in poor labor productivity is in fact not a problem because of the cheap labor supply. In terms of export potential, China's technology gap is very small if it exists at all for many categories of the clothing industry, but for most consumer electronics products and a few apparel items it will be difficult for China to acquire the necessary large-scale productive technology before the early or mid-1990s. For motor vehicles, however, it will be difficult for China to close the technology gap for low-end inexpensive automobiles and trucks before the year 2010, unless China makes an extraordinary effort to modernize the industry in the 1990s.

China's technology gap in the three industries reviewed in this study is instructive. China's technology gap with Japan and the industrialized West is large in terms of basic research and development and in terms of the ability to produce sophisticated plant and equipment from indigenous resources. A second critical dimension of China's productivity gap is the efficient use of intermediate inputs, especially energy. Finally, a third form of technology gap exists for labor productivity, but this gap is largely irrelevant for China in the foreseeable future because of the large low-cost labor force.

It must be noted that because of China's size, the token presence of some productive capacity, either imported from abroad or developed in a domestic laboratory, is not a sign that technology transfer has successfully taken place. A distinction must also be made between technology transfer guaranteeing quality production on a significant scale, and technology transfer which conserves on labor inputs. Some technologies guarantee output quality, others reduce labor costs. China needs the former but not the latter, and so what might be viewed as a technology gap resulting in low labor productivity is for China not a relevant productivity gap at all. China's technology gap is in the core quality-control technology, not in the labor-saving technology often associated with it, and this has important implications for technology acquisition.

In terms of the three industries under review, China has very little technology gap in apparel, but roughly a ten-year gap for basic consumer electronics such as radios and light bulbs. For more advanced consumer electronics, such as phonograph turntables, and for all motor vehicle-related commodity groups, China lags behind the West, Japan, and even South Korea by as much as 25 years, and should not be a factor in the international market until well after the turn of the century.

1.9 Projections of China's economic growth and trade to the year 2000 show that technology transfer could mean significantly higher growth for processed foods, consumer manufactures, and producer machinery. Exports in these sectors would also grow much more rapidly with significant technology transfer than without. In spite of the high growth results obtained when compared to the World Bank and Stanford (Professor Lawrence Lau)

projections, a review of the model's methodology and assumptions reveals that even these Rock Creek Research results may be conservative.

Using the 11-sector Rock Creek Research model of the Chinese economy, the report presents two projections reflecting high and low levels of technology transfer to China. The 11 sectors allow analysis of problems relating China's agriculture and industry, machinery and consumer manufactures, and energy. The core of the model is the measurement of historical trends of capital productivity change, which have been very high in the 1980s. Unlike the other models reviewed in Chapter 2, Rock Creek Research projections draw on data as recent as the last quarter of 1985, and explicitly measure and project not only capital accumulation trends but also trends in the productivity growth of the national capital stock. Macroeconomic evidence from the early 1980s points to gains for overall growth of as much as 7 percent per year from increased productivity, signifying a broad-based growth potential.

Results of the modeling show that China's economy will almost certainly grow at rates well in excess of official targets and related World Bank projections. Even the Rock Creek Research Low Scenario has gross output of industry and agriculture quintupling by 2000 rather than quadrupling, as in the official targets. In the High Scenario this official benchmark increases by more than six-fold, and the related trade projections, especially of manufactured consumer goods and machinery, grow even faster.

The Rock Creek Research projections appear to be high only because of the somewhat outdated projections with which they are compared--projections which have not fully incorporated the growth lessons China's recent economic experience offers.

CHAPTER 2

REVIEW OF FOUR LONG-TERM PROJECTIONS FOR CHINA'S ECONOMY

This chapter reviews four projections of China's economy to the year 2000: the official Chinese targets, projections by the World Bank, projections done for the U.S. Department of State by Professor Lawrence Lau of Stanford University, and projections by Rock Creek Research, Inc. done for this report. The last three provide a comprehensive system of projections, but the official targets seem to have very little systematic theoretical methodology, either economic or engineering. The official targets nevertheless represent an important part of the projection spectrum and are a useful basis for understanding the others, especially the World Bank's projections, which are in essence an extension of the official targets. The Rock Creek Research projections are based on a model and sets of assumptions presented in greater detail in Chapter 9, below. Only a summary of those results is presented for comparison purposes here.

In reviewing the methodology of these four projections, it becomes clear that they vary in the degree they depend on personal and expert judgement on the one hand and computerized formulations and simulations on the other. The official targets apparently depend most on human judgement, and Lau's work depends most on the econometric forward projection of past trends. Work by the World Bank and Rock Creek Research falls between the two extremes, with neither drawing heavily on past long-term Chinese trends.

The modeling efforts vary also in their relationship to formal economic theory, although all (with the exception of the official targets) are essentially governed by the accumulation of capital stock to some degree. Lau's model is the most closely tied to economic theory in a formal sense, although his framework becomes simplified in the actual simulation work. The World Bank's model is by far the most comprehensive and complex and places a great deal of emphasis on the distribution of output among different domestic sectors, but its theoretical foundation is essentially "weaker" than even Lau's (although such "weakness" may be a strength for practical purposes; see section 2.2, on modeling methodologies, below). The Rock Creek Research model is less detailed in its specification of sectoral capital stock growth, but includes a theoretically flexible component -- disembodied technical change -- which allows some consideration of the impact of technology transfer on China's overall future productivity.

In models such as these with only capital stock and changes in capital stock productivity as formal determinants of growth, changes in capital stock productivity are sometimes referred to as "disembodied technical change" because they are not specifically embodied in new equipment or buildings. This productivity change can be extremely important for understanding historical growth trends. It is described in greater detail in Chapter 9, below. Summarized briefly, it has numerous causes, including increased labor intensity, accumulation of skills, better quality capital goods for the same investment, higher rates of capacity utilization, weather variations, improved energy efficiency, political stability, improved management, and greater allocative efficiency from improved market mechanisms. Not all of these factors are directly related to technology transfer, but new technology plays an important role for many, especially sources of productivity related to higher quality capital goods, skills, management, energy efficiency, and capacity utilization. Other factors clearly depend on the success of domestic economic and political reforms. For gauging the future of China's economy, the trend in all of these factors needs to be added to the influence of investment alone.

How important is disembodied technical change? From Table 9A-4 in the appendix to Chapter 9 we can see that without it, real growth of Net Material Product in 1983 would have been 6.6 percent, but with it growth was 9.8 percent, a 3.2 percent difference. In 1984, the difference was 7 percent, raising growth from what it would have been from investment alone (6.9 percent) to the actual growth rate of 13.9 percent. What will it be in the future? This is difficult to predict, but successful technology acquisition will have a major influence on the degree to which growth is driven by disembodied technical change, as opposed to investment alone.

In sum, the projections reviewed represent a range of theory, sectoral detail, practical specification, and base data. As discussed in the following sections, each reflects much more the personal judgments of the modelers and much less the technical specifications of their different models. As guides to China's future, each has its special attractions. If one feels that China ultimately will not be able to escape the pattern and pace of growth characteristic of the period before the current wave of economic reforms, the Lau projections form a good basis for predictions. If one believes that official long-term targets contain the most complete information on China's true capabilities, then the World Bank results offer a wealth of detail made to fit exactly into the official goals. If one believes that official targets are conservative, perhaps purposefully so, and that recent economic trends have revealed a potential for growth unrealized before 1983, then the Rock Creek Research projections provide rough orders of magnitude for the shape of China's economy in the year 2000.

2.1 A Comparison of Different Projections

In terms of actual projections, Lau's are the most conservative, showing lower growth and lower trade levels by 2000. The Rock Creek Research projections are the most optimistic, and together the Lau and Rock Creek projections bracket the World Bank simulations, which maintain their close relationship with official Chinese targets. This relation of the different projections mirrors the data base from which each was made. The Lau projections are based on data going back to the 1950s, and the econometric estimates appear to be based mostly on data only through 1978, much of it estimates from before the period when official data were available.

Projections in the most recent simulations appear to be based on 1983 data. The World Bank projections were completed in the winter of 1984-85 and are also based on 1983 as the most recent year of actual data. The Rock Creek Research modeling incorporates historical information through the second half of 1985, when the economy shifted from economic boom to significant slowdown.

A comparison of GDP growth projections is given in Table 2-1, below, which shows average annual growth rates for GDP and its three major subdivisions from 1981 to 2000.

Table 2-1
Comparison of Real GDP Growth Projections, 1981-2000

	Agriculture	Industry	Other	Total
World Bank Quadruple	4.9	7.1	7.6	6.6
L. Lau High Scenario	3.4	7.9	6.7	6.7
Rock Creek Research Low	5.7	7.7	9.3	7.8
Rock Creek Research High	5.7	9.3	9.8	8.7

SOURCES: World Bank, **China, Long-Term Prospects**, 1985, L. Lau, **A Model of the Chinese Economy**, unpublished, 1985, and Chapter 9 in this report.

As shown in Table 2-1, above, the World Bank and Lau projections have nearly identical overall growth rates for the economy -- essentially the level of growth needed to reach the official targets of quadrupling gross farm and industrial output. The two differ in their projections for the components of GDP, especially for agriculture, which is significantly lower in the Lau results. In general, the Lau projections reflect the Chinese experience in the Maoist period, while the World Bank estimates reflect the productivity growth already apparent by the early 1980s. It is also important to note that the World Bank model uses prices from the early 1980s while Lau's are those of a decade earlier, when farm prices in particular were lower. This enhances the importance of agricultural growth in World Bank measures for total growth of the economy.

The Rock Creek Research growth projections, in turn, reflect information from the 1983-85 period, and, more importantly, are based on modeling of actual planted area and value yields. One of the important long-run sources of growth in the value of Chinese farm output is the shifting of land from grain to vegetables and fruits. The Rock Creek Research modeling shows that even for moderate shifts in planting patterns the impact on total crop output value is large.

In addition to somewhat higher rural output than the World Bank projections, the Rock Creek modeling also results in higher growth for services. Service sectors include health, education, housing, financial services, government administration, entertainment, transportation, commerce, restaurant services, and a range of other activities. Although there are no official value time series published for these sectors because they are considered "non-productive" by the Marxist accounting system, there are nevertheless indicators, such as employment and clientele, which allow estimates of their growth.

The relatively rapid growth for services in the Rock Creek Research projections is based both on recent indicator trends and on a comparison of the very low level of service industry output in China compared to the norm for most other economies in the world. This is a result of the deemphasis of services during the Maoist period of economic planning, in particular during the Cultural Revolution. For China to return to some level of service industry output representative of its income level, growth must be higher than that of the economy as a whole for quite some time. As a result, the service sector can be expected to lead China's growth for much of the remainder of the century.

The two Rock Creek Research scenarios are based on different assumptions about success in technology transfer from the West and Japan. Comparing the two Rock Creek Research growth scenarios, the clear difference is for growth of industry, which unquestionably is the sector most directly influenced by technology transfer. The Low Scenario projections estimate industrial growth at a somewhat lower level than the Lau modeling, but higher than estimates by the World Bank. The High Scenario results in industrial growth of over 9 percent a year, which is still considerably lower than the record of industrial growth for Japan and South Korea in their periods of most sustained rapid growth.

Just as output projections differ, so do projections of foreign trade, and in particular projections of exports. Comparisons are more difficult for trade because the selection of sectoral components is different for each model. Nevertheless, crude comparisons can be made for all three, and more detailed comparisons can be made of the World Bank and Rock Creek Research scenarios. The first set of comparisons is presented in Table 2-2, below.

Table 2-2
FOUR PROJECTIONS OF REAL EXPORT GROWTH, 1981-2000
(Percent Annual Average Real Growth)

	Foods	Crude Products	Fuels	Other	Total
World Bank Quadruple	5.7	7.5	-7.0	9.7	9.0
L. Lau High	3.0	3.1	-.3	3.3	2.8
Rock Creek Research Low	2.2	6.1	8.3	7.9	7.6
Rock Creek Research High	2.2	6.0	8.2	11.0	10.5

SOURCES: See Table 2-1, above.

Overall, the Lau projections are the lowest, showing less than 3 percent real growth in exports between 1981 and the year 2000. The World Bank 9 percent average growth rate is bracketed by the Rock Creek Research Low and High estimates. One striking difference among the projections is their estimates for fuel exports. There is no detailed breakdown for the Lau results, but the World Bank projections assume a decline in crude oil exports and no growth for coal, while the Rock Creek Research scenarios anticipate stable crude oil exports but significantly increased coal exports. On the other hand, Rock Creek Research estimates of food exports are lower than for the other two projections. Industrial exports are lumped in the "other" category and reflect basic differences in overall export projections.

Further industrial detail can be seen in a comparison between the World Bank and Rock Creek Research results, for which the Lau model is not sufficiently disaggregated. The comparison is presented in Table 2-3, below.

Table 2-3
DETAILED TRADE PROJECTION COMPARISONS, 1981-2000
(Percent Annual Average Growth)

	Agri- cul- ture	Food Proces- ing	Energy	Machi- nery	Consumer Manu- factures	Other	Total
World Bank Quadruple	6.0	9.0	-7.0	15.2	8.3	7.7	9.0
Rock Creek Research Low	2.2	6.9	8.3	8.2	8.3	3.6	7.6
Rock Creek Research High	2.2	9.0	8.2	11.2	11.5	3.8	10.5

SOURCES: See Table 2-1, above.

In general, in addition to the differences already mentioned with respect to Table 2-2, the major differences between the World Bank projections and the Low Scenario Rock Creek Research estimates are for food processing, machinery, and "other" sectors. Among these, by far the greatest difference is for machinery exports, which the World Bank scenarios all have growing at very high rates for the duration of the period. At 15 percent annual growth, World Bank machinery exports grow at nearly double the Rock Creek Research Low Scenario rate and at more than 4 percent greater than the High Scenario estimate. The World Bank result reflects the modeling linkage in the formal model between gross value output and exports, which is hypothesized to be a fixed ratio. The growth in exports therefore reflects the very rapid growth of machinery production in the World Bank projections.

The Rock Creek Research High scenario differs from the World Bank projection mainly in the higher growth for consumer manufactures, a result of assuming successful technology transfer for sectors such as consumer electronics, textiles, and clothing. Given the large weight of such exports in China's total trade, higher sectoral growth trends have a significant influence on the growth trend of trade overall.

In sum, the growth projections of all three models and the official targets differ in ways that reflect their modeling methodologies and their assumptions about China's future productivity growth and investment behavior. In order to understand the differences among the projections, these topics deserve more careful attention and are treated in greater detail in the sections which follow.

2.2 Modeling Methodologies

Comparison of these four sets of projections reveals the essential nature of such modeling and the importance of subjective value judgments in determining the overall results, even for the most theoretically complex or sectorally complete models.

In the simplest terms, the models here are different mechanisms for applying educated economic common sense and expert sectoral information in a systematic way. Common sense and the sectoral information dominate, while the system used to organize the information is of secondary importance. The modeling system is at the same time reassuring, however, because it multiplies the number of interrelated factors which must individually satisfy independent judgments. In this sense, then, official targets, in their extreme simplicity, are the least satisfactory, and the World Bank projections, with their many sectoral and causal linkages, should be the most reassuring. But since the overall results of the World Bank projections were made to match the official targets, it is clear that complexity and consistency themselves can be manipulated to fit predetermined conclusions. As we will see, this generalization holds for projections of different sectors and variables (such as exports) as much as it holds for the overall record of the most aggregated indicators.

This section will discuss several fundamental methodological issues and then briefly use them to describe the models and projections under review. The issues relate to (1) the kinds of rules which make up the models, (2) the distinction or lack of distinction between discretionary trends and trends calculated by the model, (3) the substantive importance of the flexibility of the models and their ease of manipulation, and (4) the different sources for independent or expert opinion used for adjusting and manipulating the results.

2.2.1 Modeling Rules (Equations)

The rules governing economic models are well known and can be listed as technical (e.g. relating capital stock and output), behavioral (e.g. relating personal income and consumption patterns), and accounting (most importantly, the rule that output, domestic consumption and net exports must add up). Excluding the official targets, for which there is no known model, technical and accounting rules dominate the models under review. Only in the World Bank model is consumption behavior explicitly modeled, while the Rock Creek model is limited to a monitoring through inspection of per capita consumption levels in individual sectors.

The accounting rules are similar for the World Bank and Rock Creek models, with output, intermediate use, final use, and net exports in real terms consistent for each sector, and with final use composed of allocations for investment and final consumption. Just as input-output coefficients change over time, so do the value-added shares of gross output. The accounting relationships in Lau's model are obscured by the econometric tradition on which the model is based. For example, there are no rules relating gross output, intermediate output, final use, and net exports, either for individual sectors or for the economy as a whole. Similarly, although input-output coefficients in the Lau projections implicitly change as prices change, value-added coefficients are assumed constant over the duration of the projection period. There is therefore less assurance that the Lau results are internally consistent in this, perhaps insignificant, sense.

The technical rules which are most important for all four models relate output to capital stock and to the intermediate use of raw and semi-processed inputs. In more technical terms, each model depends on projections of capital-output ratios and input-output coefficients. If the capital stock for a sector or for the economy as a whole increases, so does output, which in turn requires additional inputs of intermediate goods, such as energy. In the World Bank and Rock Creek models, both the capital-output ratios and the input-output coefficients change over the more than fifteen-year projection period, to reflect changes in technology. The intermediate-use flows are estimated explicitly. In the Lau model, the changes in these coefficients are implicit, as output is explicitly dependent on a relationship between output and prices of inputs, presumably observed over a period of years in Maoist China. In each case, the underlying technical relationship is between output and inputs, specifically capital services and raw materials.

In none of the models are labor inputs important for determining the level of output. This reflects the common assumption that although there may be a lag in the acquisition of skills, labor in China is not ultimately an input in serious shortage.

In terms of economic theory, rules of models such as these can be judged by the way in which investment levels are set, the degree that prices are important causal factors in the projection results, the provision made for output increases over-and-above those expected from increases in inputs alone, and the degree to which consumer choices determine the output and importation of consumer goods.

Investment levels in the World Bank and Rock Creek models are essentially determined by the domestic savings behavior of the economy, although the World Bank model also makes explicit the contribution of foreign savings. Linking investment to savings is one of the oldest and most fundamental relationships in macroeconomic theory. The Lau model, again reflecting its econometric roots, determines investment as proportions of heavy industrial output (capital goods and construction sectors) and imports of capital goods, again based on Maoist-era relationships (1950-73).

As mentioned above, prices are important in the Lau model because it is based on a special production relationship (Cobb-Douglas over capital and intermediate inputs) which requires that the current outlay for an intermediate input remain constant as a share of total production. This implies that if the price of an input increases, the input level must decline by the same percentage and hence output must decline, since it has fewer inputs. This is a special (and, given the Chinese real-world context, somewhat rigid) theoretical feature of the Lau model; prices in this sense are not significant for either the World Bank or Rock Creek projections.

A third theoretical relationship or rule reflects output increases not related to increases in inputs or capital stock growth -- often called disembodied technical change. Both the World Bank and Rock Creek models make explicit provision for this effect by allowing for changes in the capital-output coefficients and input-output coefficients over time. Although the Lau model does make changes in input-output coefficients implicit as prices change, the significance for technical change is not apparent, and there is no provision for an explicit enhancement of capital productivity over time, although it implicitly varies in ways difficult to monitor. There is no formal disembodied technical change coefficient in the Lau model production functions (that is, a productivity coefficient related to the time trend).

Finally, as mentioned above, consumer behavior is explicit only in the World Bank model, for which final per capita consumption in individual sectors is determined by personal income through elasticities of consumption with respect to that income.

In conclusion, the rules used to form the four models have many common features and underlying relationships, but while the World Bank and Rock Creek Research models are based more explicitly on input-output accounting relationships and explicit capital-output ratios, the Lau model has made these linkages implicit in an econometric model formally linking output to prices as well as to investment. There is logical justification for each approach, but as we shall see below, logical justification is not the only criterion for evaluating a model and its projections.

2.2.2 Discretionary vs Modeled Results (Exogenous and Endogenous Variables)

Because various rules such as those described above determine some trends from data given about others, it is tempting to conclude that some trends are determined by the person doing the modeling (the discretionary or exogenous ones) and that the remaining trends are calculated by the model (the modeled or endogenous trends). This perception would lead one to conclude that the model itself is central to the results obtained, because it generates the results based on assumptions about more fundamental variables.

In fact, however, there is little practical distinction between discretionary and modeled results; to an important degree they are all discretionary. This is because the modeler has assumptions about the so-called modeled (endogenous) results as well as the formally discretionary (exogenous) ones, and if the trends generated by the mechanical modeling process do not conform with the modeler's predetermined expectations about what is reasonable, the "assumptions" will be adjusted until the "results" conform more with what the modeler thinks they should be.

In other words, if the "assumptions" are continuously adjusted until the "results" fit into an a priori acceptable range, the roles of assumption and result have been reversed. The formally exogenous trend is determined by what it must become to generate the formally endogenous trend desired.

This observation, that nothing is really "determined by the model," is important, because it emphasizes the dominant role played by judgement and expert outside opinion in any useful modeling work. Although it is true that the technical, behavioral and accounting relationships in a model place limits and restrictions on what independent judgement can posit about an economy's future, the general thrust of the overall modeling results is determined by the modeler.

This observation, in turn, is important for all four of the projections reviewed here. The official targets represent the simplest model of all: simple judgement calls about prospects for the economy in the year 2000 with a "result" that there has to be energy conservation. But energy conservation projections fit a priori measures of China's current energy inefficiency, and it is useless to consider which result is cause and which effect. For the World Bank model, explicit descriptions of the way the model works and how contradictions are resolved make it clear that all variables are under scrutiny, whether formally exogenous or endogenous, to check their consistency with what is considered normal for other developing countries comparable to China.

Similarly, the Rock Creek Research projections depend on assessments of results with many criteria outside the formal modeling process, with adjustments made until "results" match their reasonable range by those outside criteria. For the Lau model and the description of its operation, there is less direct confirmation that all-around adjustments have been made to match all-around outside convictions. But the large number of coefficients listed in the model specifications not justified by reference to historical regression results implies that these coefficients are adjusted until "something" is right, and this author's experience and exposure to countless econometric modeling exercises of a similar nature strengthen the conviction that the Lau model also is based on this same principle.

It should be emphasized that this use of outside information to adjust "results" until they fit predetermined opinions is a sign of good modeling. A model can often produce results which are patently wrong because of the sensitivity of the specification to certain variables not considered crucial to the modeler. The results need to be reviewed in light of information too complex for formal specification. Often the "results" of the model force a reevaluation of predetermined convictions about what is a realistic range for some variable. Before the issue is resolved, though, the human judgement must be satisfied, and when it is, soundness of overall results is more likely.

2.2.3 Causal Flexibility in the Formal Models

A direct conclusion of the generalization that no trends in a projection exercise are determined by the model is the need to make models easy to use so that formally discretionary variables can be manipulated and interpreted to ensure that their values are within some acceptable range. Put another way, certain unstable features of many models must be corrected for in the specification of the model. If they are not, and the model remains unstable in its response to manipulations intended to make all results "reasonable," the process of modeling becomes frustrating and eventually exhausting and inconclusive.

It is interesting that both the World Bank and Rock Creek Research models have explicit elements which permit the damping and the spread of formally endogenous results. It is also significant that in both these models the many exogenous parameters have explicit real-world interpretations, so that when adjustments are made to get "results" which fit expected ranges, the adjustments themselves can be evaluated against real-world expectations for their values.

In the Lau model the provision for this adjustment process is not apparent, and the many coefficients which appear to be exogenous and responsible for the final results of the model have few if any easily understood real-world interpretations with independently observable values. As a result, it is difficult to know whether the adjustments made to arrive at the final results are in and of themselves reasonable.

2.2.4 Criteria for Independent Evaluation of Results

What are the usual criteria for judging the soundness of modeling results and assumptions alike? They are essentially of two kinds: the experience of other economies under similar circumstances, and the past experience of the economy under investigation. In a secondary sense, the opinions of others better able to make judgments based on these criteria is a third source of information.

For these China projections, both major sets of criteria are important. At one extreme, the Lau projections are firmly rooted in China's Maoist-era experience, while at the other extreme, the World Bank relationships have been systematically compared with the experiences of many other economies for which the World Bank has data. The official targets undoubtedly relied on expert opinion from sectoral specialists in the various industries to say what was reasonable at the time they were made (1982). The Rock Creek Research criteria rely both on the experience of other economies, especially those in East Asia, and on the more recent experience of China under post-Mao reforms.

2.3 Statistical Details for the Four Projections

The four projections (official targets, World Bank modeling, Lawrence Lau projections, and Rock Creek Research results) are presented in summary form here. For more detail on the Rock Creek Research methods and results, see Chapter 9.

The official Chinese projections for the year 2000 are simple and relatively unadorned, especially when compared to the great detail published in association with the Seventh Five-Year Plan covering the 1986-1990 period. The official targets for 2000 call for quadrupling the gross value output of agriculture and industry and doubling the output of primary energy.

A few comments about these targets are necessary. In the first place, they are round-number targets useful in speeches and as a popular call for China's goals at the end of the century. They are really slogans rather than projections. To fit well into official documents and speeches, it is preferable that slogans be whole numbers, without fractions, and so the choices presumably were to double, triple, quadruple, or quintuple SOMETHING by the year 2000. The choice of quadrupling output is natural because it is high enough to boost China in the direction of the industrialized world, but not so high as to be difficult to reach.

The choice of WHICH output to quadruple is also interesting. Quadrupling gross value of agriculture and industry will be much easier to do than, say, quadrupling GDP, because gross value output includes double counting of intermediate inputs, and the double counting increases with time as a country develops. Thus, by quadrupling gross value of agriculture and industry, China will not have to quadruple GDP. By expressing the slogan/target in this way, Chinese officials have made it easier to succeed in reaching their goal, which is good both for public morale and for leadership tenure.

A second component of the official targets is the goal of doubling gross output of primary energy by the end of the century. This is also a slogan, which even when it was made was well below the output expectations of Chinese industry specialists. This is particularly true for coal production. Targets set before 1982 were for far more than doubling output, and trends in the early 1980s nave confirmed the justification for this optimism. Just as the 1981-85 Five-Year Plan was fulfilled more than a year ahead of time with very beneficial public relations results for the reform leaders, so the slogans for the year 2000 seem to have been made more for political purposes than out of economic convictions. As predictors of China's future economic level, they are almost certainly self-servingly conservative by a wide margin.

In spite of these qualifications, however (or rather, through an understanding of these qualifications) the official targets offer considerable information. They reflect what informed Chinese are willing to predict about their economy. Through these targets they are saying that the Chinese economy will do at least that well with a high degree of certainty. This is the third kind of outside information, mentioned above, which one can use to evaluate modeling "results." Official targets become one of many benchmarks, then, for evaluating the results of the four other projections.

The tables which follow summarize the main modeling results of the World Bank and Lawrence Lau projections. Some summary is given for the output projections of the Rock Creek Research model. For Rock Creek Research trade projections, see Chapter 9. Note that for all three there are high and low projections, see Chapter 9. Note that for all three there are high and low projections, though in the World Bank case, the scenarios are called "quadruple" and "balanced."

Table 2-4
WORLD BANK QUADRUPLE SCENARIO: GDP COMPONENTS

	Agriculture	Industry	Other	Total Yuan GDP	Per Capita $ GDP	Exchange Rate
1981	159	179	120	458	301	1.54
1990	243	349	237	829	498	1.54
2000	390	657	481	1,529	831	1.54

UNITS: GDP components and total in billion 1981 Yuan; Per capita GDP in 1981 yuan, and the Exchange rate in 1981 yuan per 1981 dollars.

Table 2-5
WORLD BANK QUADRUPLE SCENARIO: GDP COMPONENT GROWTH

	Agriculture	Industry	Other	Total GDP	Per Capita GDP
1981-1990	4.9	7.7	7.8	6.8	5.8
1990-2000	4.8	6.5	7.3	6.3	5.3
1981-2000	4.9	7.1	7.6	6.6	5.5

UNITS: Percent annual average growth.

Table 2-6
WORLD BANK BALANCE SCENARIO: GDP COMPONENTS

	Agriculture	Industry	Other	Total Yuan GDP	Per Capita $ GDP	Exchange Rate
1981	159	179	120	458	301	1.54
1990	249	315	272	835	502	1.54
2000	360	544	639	1,543	839	1.54

UNITS: GDP components and total in billion 1981 Yuan; Per capita GDP in 1981 yuan, and the Exchange rate in 1981 yuan per 1981 dollars.

Table 2-7
WORLD BANK BALANCE SCENARIO: GDP GROWTH

	Agri- cul- ture	Indus- try	Other	Total GDP	Per Capita GDP
1981-1990	5.1	6.5	9.5	6.9	5.9
1990-2000	3.8	5.6	8.9	6.3	5.3
1981-2000	4.4	6.0	9.2	6.6	5.6

Table 2-8
LAWRENCE LAU BASELINE SCENARIO: GDP COMPONENTS

	Agri- cul- ture	Indus- try	Other	Total Yuan GDP	Per Capita $ GDP	Ex- change Rate
1981	118	216	102	437	284	1.54
2000	222	897	345	1,464	779	1.54

UNITS: GDP components and total in billion 1981 Yuan; Per capita GDP in 1981 yuan, and the Exchange rate in 1981 yuan per 1981 dollars.
SOURCE: Lawrence J. Lau (Stanford University), An Econometric Model of China, Final Report, Part II, U.S. Department of State, 1985

Table 2-9
LAWRENCE LAU BASELINE SCENARIO GROWTH

	Agri- cul- ture	Indus- try	Other	Total GDP	Per Capita GDP
1981-2000	3.4	7.8	6.6	6.6	5.5

UNITS: Percent annual average growth.

Table 2-10
LAWRENCE LAU HIGH SCENARIO: GDP COMPONENTS

	Agriculture	Industry	Other	Total Yuan GDP	Per Capita $ GDP	Exchange Rate
1981	118	216	102	437	284	1.54
2000	222	916	351	1,489	793	1.54

UNITS: GDP components and total in billion 1981 Yuan;
Per capita GDP in 1981 yuan, and the Exchange rate
in 1981 yuan per 1981 dollars.

Table 2-11
LAWRENCE LAU HIGH SCENARIO: GDP COMPONENT GROWTH

	Agriculture	Industry	Other	Total GDP	Per Capita GDP
1981-2000	3.4	7.9	6.7	6.7	5.6

UNITS: Percent annual average growth.

Table 2-12
ROCK CREEK RESEARCH HIGH SCENARIO: GDP COMPONENTS

	Agriculture	Industry	Other	Total Yuan GDP	Per Capita $ GDP	Exchange Rate
1981	141	184	165	490	273	1.79
1990	257	501	453	1,211	578	1.89
2000	407	1,000	967	2,374	997	1.93

UNITS: GDP components and total in billion 1981 Yuan;
Per capita GDP in 1981 yuan, and the Exchange rate
in 1981 yuan per 1981 dollars.

Table 2-13
ROCK CREEK RESEARCH HIGH SCENARIO: GDP COMPONENT GROWTH

	Agri-culture	Industry	Other	Total GDP	Per Capita GDP
1981-1990	6.9	11.8	11.9	10.6	9.4
1990-2000	4.7	7.2	7.9	7.0	5.8
1981-2000	5.7	9.3	9.8	8.7	7.5

UNITS: Percent annual average growth.

Table 2-14
ROCK CREEK RESEARCH LOW SCENARIO: GDP COMPONENTS

	Agri-culture	Industry	Other	Total Yuan GDP	Per Capita $ GDP	Exchange Rate
1981	141	184	165	490	273	1.79
1990	258	483	448	1,189	572	1.88
2000	405	756	887	2,048	907	1.83

UNITS: GDP components and total in billion 1981 Yuan; Per capita GDP in 1981 yuan, and the Exchange rate in 1981 yuan per 1981 dollars.

Table 2-15
ROCK CREEK RESEARCH LOW SCENARIO: GDP COMPONENT GROWTH

	Agri-culture	Industry	Other	Total GDP	Per Capita GDP
1981-1990	6.9	11.3	11.7	10.4	9.1
1990-2000	4.6	4.6	7.1	5.6	4.4
1981-2000	5.7	7.7	9.3	7.8	6.6

UNITS: Percent annual average growth.

Table 2-16
LAWRENCE LAU BASELINE SCENARIO: EXPORTS

	Foods	Crude Products	Fuels	Other	Total Exports
1981	2.92	2	5.12	11.52	21.56
2000	5.58	3.76	4.38	22.75	36.47

UNITS: Billion current dollars
NOTE: Sectors are based on SITC groupings:
SITC 0-1; 2,4; 3; 5-9

Table 2-17
LAWRENCE LAU BASELINE SCENARIO: EXPORT GROWTH

	Foods	Crude Products	Fuels	Other	Total Exports
1981-2000	3.0	3.1	-.3	3.3	2.8

UNITS: Percent annual average real growth (based on trade measured in constant 1972 dollars)
NOTE: Sectors are based on SITC groupings:
SITC 0-1; 2,4; 3; 5-9

Table 2-18
LAWRENCE LAU HIGH SCENARIO: EXPORTS

	Foods	Crude Products	Fuels	Other	Total Exports
1981	2.92	2.00	5.12	11.52	21.56
2000	5.58	3.76	4.38	22.75	36.47

UNITS: Billion current dollars
NOTE: Sectors are based on SITC groupings:
SITC 0-1; 2,4; 3; 5-9

Table 2-19
LAWRENCE LAU HIGH SCENARIO: EXPORT GROWTH

	Foods	Crude Products	Fuels	Other	Total Exports
1981-2000	3.0	3.1	-.3	3.3	2.8

UNITS: Percent annual average real growth (based on trade measured in constant 1972 dollars)

NOTE: Sectors are based on SITC groupings:
SITC 0-1; 2.4; 3; 5-9

Table 2-20

WORLD BANK QUADRUPLE SCENARIO: EXPORTS

	Crops	Animal Hus-bandry	Metal-lurgy	Elec-trici-ty	Coal	Crude Oil	Refin-ed Oil	Chemi-cals	Machi-nery	Build-ing Matrls	Food Proces-sing	Tex-tiles	Other Manu-factures	Con-struc-tion	Trans-port	Commerce
1981	2.19	.83	1.75	.00	.33	1.58	1.21	2.96	4.34	.19	2.65	10.99	3.51	.00	2.46	3.45
1990	6.07	1.56	1.70	.00	.24	1.48	.23	3.94	18.73	.68	6.21	18.23	10.60	.00	5.27	7.38
2000	5.86	3.26	3.31	.00	.37	.00	.42	9.00	63.44	1.76	13.68	33.69	32.63	.00	12.67	17.72

UNITS: Constant 1981 yuan.

Table 2-21
WORLD BANK QUADRUPLE SCENARIO: EXPORTS

	Foods	Crude Products*	Fuels	Other	Total Exports
1981	3.08	.49	.12	18.81	22.50
1990	9.11	1.03	5.04	53.34	68.53
2000	19.18	4.17	34.57	221.11	279.04

UNITS: Billion current dollars

NOTE: Sectors are based on SITC groupings:
SITC 0-1; 2.4; 3; 5-9

*NOTE: Rock Creek Research calculation from World Bank category data

Table 2-22
WORLD BANK QUADRUPLE SCENARIO: EXPORT GROWTH

	Foods	Crude Products	Fuels	Other	Total Exports
1981-2000	5.7	7.5	-7.0	9.7	9.0

UNITS: Percent annual average real growth (based on trade measured in constant 1981 dollars)
NOTE: Sectors are based on SITC groupings:
SITC 0-1; 2,4; 3; 5-9

CHAPTER THREE

THE CLOTHING INDUSTRY

China has managed to develop its apparel industry into a significant force in world markets. Building on accumulated technical and managerial experience, and relying to a large degree on imports of production technology and equipment, China is increasingly able to compete with other Asian garment manufacturers.

Very low worker productivity in the apparel industry is more than offset by low labor costs, which make Chinese garments very price competitive in world markets. China's low labor productivity technology does not reflect a technology gap in terms of product quality, but is rather a technical accommodation to the plentiful cheap labor supplies. In terms of its importance for product quality and export competitiveness, then, production technology and the size of a technology "gap" are not as critical for the clothing industry as for the consumer electronics and motor vehicles industries.

In addition to low labor costs, the high quality of inputs and processing operations strengthens China's competitive position. Fabric inputs and textile processing abilities, both major determinants of quality levels in the apparel industry, are at or above acceptable levels of qualities, largely because of successful import absorption.

Japan has moved far up the value-added ladder in apparel. Japanese garments are now priced so high, due to high labor and capital costs, that they are increasingly relegated to the role of small-scale production of specialty items. South Korea is having difficulties digesting imported technology and moving up the value-added ladder to high-grade garments, and is facing pressure from lower cost producers such as China. Korea's problems, however, appear to be managerial and are not likely to prove such a drag on the development of the Chinese industry.

China's export potential in the clothing sector, barring non-technical factors such as protectionism, is excellent. With or without major imports of technology, China will prove to be a very important exporter of low-cost, low-, medium-, and high-grade apparel to OECD markets. Having already achieved import penetration, continued exports in the short term are assured. It is highly likely that China's export position in the intermediate-term will remain strong.

3.1 Historical Growth Patterns of the Clothing Industry

China has a long history of clothing production. Traditional styles have been developed over many centuries, and have been complemented by the influx of Western fashions during the past century. By the late 1940s, both

Chinese and Western styles were manufactured with a high degree of sophistication, especially in the Shanghai area. Clothing as a means of personal expression was de-emphasized after 1949, and actively discouraged for much of the Maoist period. Deng Xiaoping's Open Door Policy has brought the textile and apparel industries back to a position of importance.

Japan's apparel industry was established at approximately the same time as China's, but developed more rapidly, in part because of government support and direction. Both Japan's and South Korea's textile and apparel industries were destroyed by war (World War II and the Korean War, respectively). With US government support, the industries grew rapidly in their post-war periods. Japan has made significant technological advances in the production of synthetic fibers and textile processing equipment; South Korea has benefitted from these Japanese advances through a process of active technology acquisition.

3.1.1 History of China's Clothing Industry

China's clothing industry has a long and varied history. Many traditional styles of clothing were, and still are, considered to be very fashionable. Both Chinese clothing and Western styles were developed to a high degree of sophistication, especially in Shanghai during the late 1940s post-war period. After the Communist party gained control over the country in 1949, apparel played a much less influential role in people's lives. During the extended Cultural Revolution (1966-76), any type of expression through clothing styles was actively discouraged. The clothing and textile industries remained essentially dormant through the whole of the Maoist period. Following Mao's death, and influenced in large part by Deng Xiaoping's Open Door policy, the fashion and textile industries experienced a renaissance.

The history of Shanghai's clothing industry is interesting as the leading center for apparel production in China and offers insight into the levels of development achieved by the nation's clothing industry as a whole. As early as the reign of the Qianlong Emperor (ca. 1795) Shanghai was the site of a flourishing trade in ready-made clothing. This trade, at a time when the overwhelming majority of clothing was sewn at home, was partly an outgrowth of the high level of sophistication of handicrafts and style in the region.[1]

Western fashions were not introduced until after Shanghai was opened to the West in the late nineteenth century. As tailors gradually familiarized themselves with Western styles, they began to produce Western as well as Chinese apparel. In 1896, the Hechang Western Clothing Store opened and became the first Western style clothing outlet in China operated by Chinese management. Women's fashions became popular in Shanghai in the early years of the twentieth century; in 1917, the Hongxiang Company stepped in to help fill this demand, and became the first Chinese-run Western fashion store. With the import of more sewing machines, Shanghai's (and China's) fashion industry grew rapidly. By 1948, the number of tailors manufacturing and retailing Western fashions and children's clothing in the city had climbed to 993. 1949 probably represented the height of sophistication for the domestic apparel industry in terms of both Chinese and Western fashions.

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[1] Much of this discussion of the history of apparel industries in Shanghai is drawn from pp. 151 and 567-68 of Shanghai's Economy (in Chinese).

These small-scale commercial developments appear to have been paralleled in the manufacturing sector. The Yunchang Shirt and Hose Factory was also opened in 1896, and was followed by the more well-known Jingluen Shirt and Hose Factory in 1902. In 1916, the first knitted goods factory was established; it was China's first automated hosiery factory. Clothing manufacturers flourished during and after the First World War. The Japanese invasion and World War II led to a collapse of the industry, however, and recovery after the war was only partial.

In 1956 Shanghai had approximately 1,500 enterprises which manufactured clothing. Of these, 21 were considered to be large-scale with over 100 employees. These 21 constituted only 1.4% of all clothing firms. There were 98 medium-scale firms with between 50 and 100 employees; the remainder were small-scale or individual enterprises with fewer than 10 employees. The vast majority of the medium- and small-scale enterprises were characterized by aging facilities, backward technology, and low labor productivity.

Much of the textile and apparel industry continued to operate largely under existing management for several years after the founding of the PRC. By 1956, however, under the new government's policy direction the industry increasingly came under joint state-original ownership management. Trade with the West was cut off by the US embargo resulting from the Korean War. Original managers and owners were for the most part cut out of the management process by the end of the 1950s. The result was greatly lessened flexibility in clothing styles, also in part a result of decreasing opportunities for social expression in an increasingly turbulent political atmosphere. With the onset of the Cultural Revolution in 1966 factories were closely supervised by ideologue supervisors; the Mao suit became the uniform of the Chinese people.

Deng Xiaoping's Open Door Policy, initiated in 1979, and the economic reforms which followed, proved a major stimulus for the Chinese apparel industry (and textile industry as well). Increased personal freedoms have gradually been expressed through a greater variety of clothing styles. Less control over retail sales and the initiation of price reform have given the Chinese consumer greater choice. Management reform has allowed textile factory managers and clothing manufacturers to be more responsive to consumer demands, both domestic and international.

While imports of technology and productive capacity increased greatly under the Open Door Policy, this did not mark the beginning of foreign trade in the apparel and closely-related industries. The Chinese government has long recognized the export potential of textiles and apparel, and has a history of export promotion. One factory, the Da Hua Shirt Factory in Beijing, began exporting shirts in 1958.

Some of the technical assistance which enabled China to raise product desirability and quality to export levels came from CMEA countries. Nylon production technology was imported from East Germany in 1957 in the form of an experimental plant. Production was begun in the 1960s, but high-volume output levels were not achieved until the 1970s, and then only with the assistance of OECD nations.[2] By 1978 China was also able to produce vinylon, polyester, and acrylic.

3.1.2 History of South Korea's Clothing Industry

After the Korean War ended, one of the obvious industries for the Korean industrial sector to target was apparel. Production capacity was required to meet growing domestic demand, and the experience of Japan had shown that textiles and apparel were industries in which low labor costs could prove to be a major advantage. Exports of low-grade apparel were supported by the US as a strategic policy tradeoff (security concerns have had a significant affect on trade policy toward both Korea and Japan). Many of the large-scale conglomerates actively pursued apparel production and exports. Aided by technology transfers from Japan, Korean garment manufacturers gradually expanded their export volumes through the 1970s and early 1980s.

3.1.3 History of Japan's Clothing Industry

Japan moved into large-scale production of textiles, and garments, relatively early. By the late nineteenth century, Japan was exporting cotton fabrics to many nations in Europe (and the US), and importing raw cotton from India to supplement domestic production. Japan's textile and apparel industries, like China's, benefitted tremendously from world demand during World War I. By the early 1920s the industry was one of the leading industries in the Japanese economy, along with paper production and shipbuilding. Chalmers Johnson notes, however, that this preeminence was not to be long-lived, "Whereas at the end of the 1920's three of Japan's ten largest enterprises were textile companies, a decade later only one was."[3] Japan's war effort led to a drastic decline in the so called "peace industries" (textiles, metals, chemicals), a decline which was difficult to arrest because of the destruction and conversion of production capacity.

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[2] Specifically, Japan, Britain, and West Germany. See Osamu Uno, "Textile China," Textile Asia, February 1983, p. 92.

[3] He continues, "Interestingly enough, the top ten of 1940 bear a much greater resemblance to the top ten of 1972 than they do to the top ten of 1929 (Japan Steel, Mitsubishi Heavy Industries, Hitachi, and Toshiba were ranked first, second, fourth and eighth respectively in both 1940 and 1972, whereas only Mitsubishi was even on the list in 1929). Chalmers Johnson, MITI and the Japanese Miracle: The Growth of Industrial Policy, 1925-1975, p. 156.

While the apparel industry was able to re-emerge from the 1940s, especially with the help of man-made fiber production, it was not to regain its former leading position. By the late 1950s Japan was importing large amounts of cotton and wool, and exporting inexpensive garments, largely to the US. Political repercussions in America led to a series of export limitation and orderly marketing agreements, both bilaterally with Japan and with other garment exporting nations. To avoid sharp cuts in the industry, Japan was forced to move into more automated production of higher-grade products. Development of a number of fine fabric combinations based on man-made fibers did help to keep textile and apparel exports alive.

3.2 Current Technology and Productivity Levels in the Clothing Industry

At present, China's apparel industry is moving forward rapidly. Backed by a strong textile industry which produces more cotton and animal hair fabrics than any other country in the world, it has developed a very substantial capacity for synthetic fiber production. Garment manufacturers are beginning to rise to the challenge of a more sophisticated domestic consumer base. In addition to addressing a growing domestic demand, the industry has become more responsive to international market forces. Quality control and styling have advanced to an acceptable level. When domestic manufacturers are unable to provide necessary inputs, the industry has shown a willingness to acquire the production technology, and occasionally inputs, from abroad. Very low worker and capital productivity is more than offset by low labor and capital costs, which make Chinese garments extremely price competitive in world markets. Clothing manufacturers have capitalized on their cost advantage, and have developed significant exports to OECD markets.

The picture is less bright for South Korean and Japanese apparel manufacturers. While both are technologically more advanced than the Chinese they are faced with diminishing export markets. Japanese labor costs have cut international price competitiveness in almost all clothing categories, with the exception of very high-grade or specialty items. South Korea has lost market share to lower cost producers, such as China and Taiwan, and has failed to improve quality levels for much of its clothing manufactures.

3.2.1 Technology and Productivity in China's Clothing Industry

China's clothing industry has attained a relatively high level of quality through technology and equipment acquisition. The domestic market is increasingly sophisticated in its demand for fine fabrics and well-made clothing. While productivity by any measure remains low throughout the industry, minimal labor and capital costs keep Chinese garments cost-competitive in international markets.

The garment industry has grown to a substantial size. There are currently approximately 8,000 clothing factories under the control of the Ministry of Light Industry, producing 800 million garments annually, or 80% of China's total garment production. Approximately 1,000 of these factories produce for the international market.[4] An increasingly greater proportion of China's population of one billion is buying ready-made clothes. Export sales are growing rapidly.

Productivity in the apparel industry (and the textile industry as well) is extremely low. Acceptable quality levels and very low labor costs allow Chinese apparel exports to remain internationally competitive. Processing operations and fabric inputs used by the industry are reported to be of medium to high quality. As expected, processing operations such as the operation of cutting and sewing machines are extremely labor-intensive. One Western expert noted that "... fundamental skill of the machine operators was of a very good order, and there was no obstacle at all to further improving the quality levels achieved, or productivity levels either."[5] He continued, "I would say that China is at 30-40% of Western productivity, Hong Kong most probably at 70-75% of the best Western performance." Shanghai, and the coastal regions in general, have higher productivity levels than inland factories, most likely due to the history of production and the ability to capitalize in those areas on the economies of scale.

Wage levels in the industry, as for Chinese industry as a whole, are extremely low compared to other Pacific Basin countries such as Japan and South Korea, and even more so in comparison to the OECD countries. Nonwovens Industry has reported figures compiled by the Ladies' Garment Workers Union which estimate the typical wage for garment and textile workers in China at 16 cents per hour, while those for Taiwan, Hong Kong, and the US are 57 cents, $1, and $5, respectively.[6] Estimates for South Korea and Japan would probably be somewhere above those for Taiwan and Hongkong, in that order. In a labor intensive industry such as garment manufacturing, where technology and manufacturing equipment is relatively mobile across international borders, very low labor costs offer a tremendous advantage.

An important determinant of the garment industry's quality levels is the quality level of the fibers and materials which go into the product. As mentioned above, the industry has gained significant experience with manmade fibers over time. In 1983 existing polyester production capacity and capacity under construction was calculated to total 970,000 tons per year, a figure exceeded only by the US and Japan. Whereas cotton comprised nearly 90% of the total volume of domestic input into production in 1976, by 1981 this had dropped to 72% while synthetic fibers had risen to approximately 20%.[7] Despite a policy of autonomous supply, at various times in recent years China has been willing to look to other suppliers for either petrochemical inputs or raw fibers. Increasingly, Chinese consumers are demanding products which are a blend of synthetic and natural fibers.

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[4] Zhang Yue, "Chinese Clothes Enter World Market," China Market, 1985(?), p. 13.

[5] "Discovering China," op. cit., p. 42.

[6] Nonwovens Industry, September 1985, p. 46.

Cotton is still king in China; it is the most important natural fiber used in the textile and apparel industries. Annual production is the highest in the world. In the late 1970s and early 1980s, demand for cotton clothing, both by domestic and foreign markets, was so far above domestic cotton production that significant volumes of cotton had to be imported. Very large increases in production from 1981 to 1984 appear to have lessened the need for imports, and imports did decrease over the period. However, figures released early this year show a steep decline in cotton production, to an amount below the 1983 figure. As a result it seems likely that 1985 cotton imports will increase dramatically.

After cotton, wool is China's most important natural fiber. China is the largest producer of animal hair (wool, angora, and cashmere) in the world. Western experts who have observed production of wool-based clothing have been very impressed with the quality of wool fabrics.[8] Many Chinese wool knit factories have been given a certificate of inspection from the International Wool Bureau. Cashmere cloth has also been very well received. Because of the quality of these fibers they are in great demand on the export market as well as the domestic market, which has in turn led Chinese textile and clothing manufacturers to experiment with various fiber compositions in their fabric designs. One Changsha firm, the Changsha Woolen Knitwear Mill, currently produces a linen-cotton-wool blended sweater. This combination has proved popular with foreign buyers. Success in the export of blends, combined with rising domestic demands for blended-fabric apparel, appears to be leading to an increase in the production of blended (both natural-natural and natural-synthetic) fabrics.

Processing quality is as important, if not more important, than the quality level of inputs. Many factories possess imported machinery, and therefore are able to cut and sew within the narrowly accepted tolerances found in Western factories. Contrary to possible expectations, those plants not equipped with technologically more advanced machinery from the West are still able to process clothing at high quality levels. One Western expert who toured a number of factories in Shanghai, Guangzhou, and Peking noted that while most of the machines were Japanese imports, some were of Chinese manufacture and did not appear to compromise quality.[9] This expert did, however, note that the finish of some products he observed leaving factories offered room for improvement. Problems were either a result of fabric or machine deficiencies, but definitive judgement was not possible. Other than occasional finishing problems, most Chinese apparel (especially that destined for export) appears to be produced at acceptable quality levels, and occasionally even at high levels.

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[7] Uno, op. cit., p. 94.

[8] "Discovering China," the text of an interview between Mr. Stig A. Kry, Chairman of the Board of Kurt Salmon Associates, Management Consultants, who specialize in the textile and clothing industries, and Mr. Kayser Sung, Editor-in-Chief of Textile Asia, in Textile Asia, September 1981, p. 42.

Indigenous design abilities are in some ways a reflection of a country's technical level in the clothing industry. It is possible for a society to produce a product which it does not use; however, familiarity with the product can decrease the effort required to deliver high quality output. The same holds true for clothing. Chinese familiarity with diverse fashions and fabrics decreases the level of effort required to design and/or produce high quality garments. The industry is doing much to promote Chinese designers: famous designers such as Pierre Cardin and Yves St. Laurent have been invited to China to exhibit their designs, indigenous designer fashion shows are being promoted in the larger cities, and a clothing design college has been founded. These measures appear to be part of a larger plan by the Ministry of Light Industry and the associated China Garment Industry Corporation[10] to encourage the development of a Chinese fashion industry.

Brand establishment is also being encouraged as a way of strengthening the garment industry's sales prospects, both domestically and internationally. This is a recognized means of promotion for Chinese apparel. At present there are no plans to decrease the use of foreign labels, because they usually already have a marketing and consumer base.

Currently several well-known American designers are having garments manufactured in China for them under license for export markets. Liz Claiborne is one of the most visible of these; she has ordered high-grade silk dresses from ten Shanghai mills through the Shanghai Import & Export Branch of the China Silk Corporation. In addition to dress production, Liz Claiborne International Ltd. plans to export ready-to-wear items and girls' apparel from Shanghai. Other designers sourcing their garments in China include The Arrow Company, Lloyd Williams, and Pierre Cardin.

Packaging and accessory items remain a problem for China's garment industry. Poor quality in the packaging industry is endemic throughout the Chinese economy. It is a problem which has been receiving more attention, especially as poor packaging leads to the erosion of vital export markets. A lack of supporting accessories such as buttons and zippers is more of a problem for those garments marketed domestically than it is for those exported.

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[9] "Discovering China," op. cit., p. 43.

[10] Established in July of 1984.

3.2.2 Technology and Productivity in South Korea's Clothing Industry

South Korea's apparel and textile industries are currently experiencing problems. Having based much of their growth in recent years on export expansion, the growing tide of world protectionism has undercut many Korean garment manufacturers. Labor costs have risen dramatically, without a commensurate increase in investment levels aimed at decreasing labor requirements, and have cut Korean competitiveness. As early as 1981 Taiwanese clothing exports to OECD markets were beginning to cut into Korean exports in this very marginal industry.

Korea's strategy has been to attempt to move up the value-added ladder in its clothing manufactures. This requires a very high level of investment, at a time when the Korean government has been tightening credit to the large industry groups such as Daewoo which are predominant in the export markets. Many of the factories are large-scale, and are designed for long production runs. This makes them much less responsive to changes in product demand, and has also been a factor in low quality levels. Many of Korea's garment exports end up in discount and lower-price stores. Daewoo has proved to be an exception (and there are others); investment was made in higher skilled workers, and has resulted in higher quality output and licensing arrangements with designer labels such as Van Heusen, Givenchy, and Geoffrey Beene. In addition, Daewoo has recognized the value of smaller shops which are generally as efficient as larger plants and much more responsive to changes in demand. To avoid the value-added trap of Japan above and China below, Korea's garment industry will have to follow Daewoo's example.

3.2.3 Technology and Productivity in Japan's Clothing Industry

Japan's current textile and apparel industries are technologically advanced. Many of the high-tech spinning, cutting, and sewing machines used throughout the international industry today are manufactured by the Japanese. This allows their garment industry to produce high quality, high cost garments for the domestic and OECD markets. South Korean and Chinese garment imports, however, raise questions about the overall competitiveness of the Japanese clothing industry. The industry is increasingly relegated to the role of small-scale production of specialty items, a role which brings the Japanese into competition with American and European clothing manufacturers. Prospects for offshore processing remain positive, however. Lower cost production in other Asian countries can be aggressively marketed through the larger Japanese trading companies which have access to OECD markets via advertising.

3.3 China's Export Potential in the Clothing Industry

China's apparel industry has already begun to make significant inroads into the OECD markets. Quality levels are sufficiently high, and should continue to increase with the continued import of production technology, equipment, and inputs such as fine fabrics and accessories. Reprocessing, which already constitutes over 15% of China's garment exports, is likely to increase--at least over the short term. Exports in the short term will for the most part remain in the lower-grade categories, and will be marketed through large retailers and discount stores.

Strategic planning by the Chinese government in the area of garment exports will allow garment manufacturers to increase the value of their exports, both by piece and in total value terms, in spite of growing quota barriers. Zhong Quansheng, Assistant General Manager of the China Textile Import-Export Co. has stated:

> "China already possesses the basic conditions for expanding her export of medium- and high-grade clothing. Thus, in terms of export strategy, we should continue expanding sales volumes of goods we export little of and increase sales to regions that have no import restrictions. But we should also shift the emphasis of our work to improving product quality and to expanding exports of high-grade clothing so as to 'succeed through quality' in the international marketplace and to improve economic results."[11]

China is aware of the value-added ladder, and is making preparations to position herself and expand exports. In the intermediate- and long-term, in the absence of major protectionist measures, China will be a major force in international garment markets.

3.4 Quantitative Prospects for Garment Exports

Although it is difficult to say what China's level of garment exports will be by the year 2000, it is possible to speculate what the levels of export to the U.S. will be, using information from Chapter 6 below and speculating about the growth of the market overall and China's success in capturing a larger market share from Japan and South Korea. In the case of garments, since China in 1985 already had between 15 and 20 percent of the joint South Korean, Japanese and Chinese market in the U.S. (hereafter referred to as "the market") China's market share should be very large by the year 2000. On the other hand, the entire market is relatively small when compared to consumer electronics and motor vehicles, so the large market share will have smaller significance for export earnings.

Focusing on just three garment categories, wool suits, non-knit shirts, and skirts, even if China fails to transfer much modern technology to its clothing industry, market share could increase from roughly 20 percent in 1985 to possibly close to 70 percent of the market by 2000. In dollar terms (1985 constant dollars), this would mean an increase of just over 300 million dollars, from 100 million to 430 million dollars, assuming the market itself grew at an annual average of 2 percent.

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[11] Zhong Quansheng, "An Examination of the Strategy for Expanding Clothing Exports," in Intertrade, as reported in FBIS, JPRS, China Report, Economic Affairs, March 19, 1985, p. 99.

On the other hand, if China is very successful in transferring technology, the results for these three categories could be somewhat better, say, an increase to nearly 80 percent of the market and an additional 70 million dollars of sales for suits, shirts and skirts.

The results for sweaters are likely to be roughly the same as for suits, shirts and skirts combined. If sweaters, suits, shirts, and skirts are combined under the high scenario assumptions, the result is over a billion dollars in exports by the year 2000, more than triple the 1985 level for just these four garment categories. In conclusion, therefore, prospects for clothing exports to the U.S., and to other markets as well, are quite good and will succeed whether or not there is much success in the transfer of modern technology.

CHAPTER FOUR

THE CONSUMER ELECTRONICS INDUSTRY

In spite of China's general reputation for employing pre-World War II technology levels in industry, China's consumer electronics industry has a long history of development mirroring, although also lagging behind, those of Korea and Japan. China's productivity and technical levels in consumer electronics vary widely from facility to facility and are backward in a significant proportion of all enterprises, but in some cases they approach standards of quality and cost-effectiveness found in Japan and the West. As a result, the prospects for China's consumer electronics sector, and in particular exports in the sector, are very good in the intermediate and long-run, and could be significant in the near future if foreign exchange is available for the importation of foreign capacity on a significant scale.

China began consumer electronics production with vacuum tubes, introduced transistor and integrated circuit technology somewhat in pace with the rest of the world, and has become one of the world's largest producers of the industry's most representative products, such as radios. China's contrast with the histories of Japan and South Korea is one of degree: the other two countries started sooner in most cases, introduced newer technologies earlier, and achieved economies of scale more rapidly.

While China does have a long record of indigenous production, large-scale production technology has generally been unable to replicate the quality prototypes produced by small-scale shops and research divisions. In this respect, China's consumer electronics industry has gained significant benefits from imported technology. For example, color television technology was developed in China sometime during the early 1970s, but commercial production was not possible until the import of assembly technology and equipment from Japan's Hitachi Electronics. It is likely that similar imports of production technology will remain very important for Chinese production capabilities for video cassette recorders and as-yet undeveloped products. Assimilation problems have arisen in the past, however, when the technology imported was too advanced to be digested rapidly.

The competitive position of China's exports in the short-run and even the intermediate-run will depend a great deal on the degree to which production technology is imported, but long-run competitiveness is assured by the existence of a well-established industry with indigenous technical levels capable of eventual modernization at a rate considerably faster than the rate of technical change at the frontier of world consumer electronics.

4.1 Historical Growth Patterns of the Consumer Electronics Industry

Although it is true that first Japan and then South Korea led China in the development of a consumer electronics industry, investigation of the history of China's sector shows that it, too, began relatively early, attained a production scale of considerable significance, and improved its level of sophistication through the Cultural Revolution and the Post-Mao period of economic and political reform. Japan has been the leader in Asia in the area of consumer electronics production and technological advancement by a large margin. The Japanese have generally been a decade or more ahead of South Korea, and even farther ahead of the Chinese, both in domestic development of a product and in export ability. However, South Korea has been able to shorten the time that Japan required between initial production and export competitiveness, usually through a process of concerted technology acquisition.

4.1.1 History of China's Consumer Electronics Industry

China's consumer electronics industry has followed an arduous development path, yet one which appears to be advancing more rapidly over time. Whereas many industries benefited from Western investment in the coastal regions during the early twentieth century, prior to 1949 there was almost no local investment and only minimal Western investment in radio broadcasting and production. Most of the few factories assembled imported Western kits, and the rest performed repair operations. One such factory, the Feiyue Electro-Acoustic Factory in Shanghai, began as a service and imported parts supplier in 1939, switched to loudspeaker and microphone production in 1948, supplemented this with radio production in 1949, and then spun off radio production several years later.

Only 4,000 radio sets were produced in 1949. In June of 1950, the Chinese began to develop their own short- and medium-wave transmitters, sparking the development of China's electronics industry. By 1952, output of radios had risen to 17,000. After 1956, investment in radio production grew rapidly, with 1957 output levels jumping to 350,000 sets (see table #1 below). Vacuum tubes were the main components (the norm for much of the world's radio production at that time), and the technical level of these sets was relatively low.

Table 1
Chinese Output of Radio and Television Sets, 1949-85

	Radio sets (thousand sets)	Television sets
1949	4.0	
1952	17.0	
1957	352.0	
1962	903.0	3.6
1965	815.0	4.4
1970	3,231.0	10.5
1975	9,356.0	177.8
1976	9,691.0	184.5
1977	10,494.0	284.6
1978	11,677.0	517.3
1979	13,807.0	1,328.5
1980	30,038.0	2,492.0
1981	40,572.0	5,394.1
1982	17,239.0	5,920.1
1983	19,989.0	6,840.1
1984	22,203.0	10,038.1
1985	15,734.2	16,217.0

Sources: 1985 State Statistical YearBook, p. 337, and
China Economic News, Jan. 27, 1986, p. 6-7.

China began to develop television in 1958, when the Peking Broadcast Equipment Factory and Broadcast Research Institute, in cooperation with Qinghua University, developed and produced 1,000 black-and-white television transmitters and the equipment for 10 black-and-white television facilities. Using this equipment, China's first television station was established in Peking in the same year. Later, the Tianjin Radio Factory became the first electronics factory to produce televisions in China, using the "Peking" trademark. By 1962, approximately 3,600 sets were being produced each year. In 1973 these original four government organizations oversaw the construction or transformation of 22 factories designed for production of television sets or television broadcasting equipment. This rapid increase in capacity has also been tied to increased local efforts by provincial governments throughout China to develop regional and local production centers.[1] Whereas production had remained low through the 1960s, with 1970 production rising to only 10,500 sets, these increases in capacity allowed for a jump in production levels to almost 180,000 sets in 1975. Production increased dramatically each year after 1975 (see Table #1, above).

Most, if not all, of China's television technology appears to have been acquired from abroad, as opposed to having been developed indigenously.

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[1] 1984 Machinery and Electronics Industry Yearbook (in Chinese), ed. by Lu Bing, Peking, PRC.

There is no information readily available detailing the transfer of technology to China from the Eastern Bloc, the most likely source of initial television broadcast and receiver technology transfers. Sales of assembled sets and kits from the Hungarian corporation VIDEOTON were begun in 1978, and have continued. Unfortunately, other than this anecdotal account of one company's involvement, there appears to be no other information about CMEA country involvement in China's consumer electronics industry.

The industry appears to have moved from vacuum tube technology to transistors in the early or mid-1960s. The Shanghai No. 3 Radio Factory claims to be the nation's first factory to build a fully transistorized radio, in 1962. In 1964, the same factory produced a small-scale fully transistorized short-wave radio receiver. By 1980, the first year for which a breakdown is available, fully 96% of radio production was based on transistor technology (see table #2, below). During the 1970s, television production was targeted nationally to move away from vacuum tubes into transistors, as a further means of developing transistor production technology on a wide scale.[2]

Color televisions were first produced in the early 1970s. Again, Shanghai appears to have been the seat of one of China's technological front-runners; in 1970 the Shanghai No. 1 Television Factory is said to have produced China's first color television sets, using semiconductor technology. By 1973 other factories in Shanghai were producing color sets and transmitters as well. In 1980, only 1% of total TV production in China was composed of color sets (see table #2, below). This figure had climbed to no more than 3% by the following year, indicating the immaturity of this technology within the industry, as well as the difficulties limiting rapid dissemination of technology, given the size of the industry.

Even though China was able to produce color televisions by the early 1970s, producing them in commercially significant numbers was not possible for another ten years and required imported technology. It is likely that the production figures for 1980 are for one or two plants alone (with a total daily production capacity of approximately 300), and might therefore reflect only the output of the Fujian-Hitachi joint venture plant credited with introducing color television production technology into China.

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[2] Shanghai's Economy, 1949-82 (in Chinese), p. 950.

Table 2
Output of Radio sets, Television sets, and Recorders, 1980-85

	Radio sets		Television sets		Recorders
	Vacuum Tube	Trans-istor	Black-and-white (thousand)	Color	
1980	1,070	28,968	2,460	32	743
1981	1,694	38,878	5,242	152	1,546
1982	820	16,419	5,632	288	3,471
1983	328	19,661	6,309	531	4,977
1984	143	22,060	8,698	1,340	7,764
1985	*	15,700	12,120	4,100	12,700

* Transistor/vacuum tube breakdown not available at the time this report was prepared.
Sources: Rock Creek Research Statistical Handbook.

As electronics factories have become more familiar with production processes and have assimilated technology acquired from both Eastern Bloc nations and the West, they have been able to begin production of somewhat more sophisticated cousins of radios and TVs: tape recorders (reel to reel and cassette) and video cassette recorders. Tape recorders were initially produced sometime in 1972, while VCRs appeared only in 1985. (These dates are for civilian production only; production for military use may have begun at an earlier date.) Production levels for tape recorders are only available beginning in 1980, when 743,000 were produced. This grew to 1,546,000 the following year, and 3,471,000 in 1982 (see table #2, above). These annual increases, both over 200%, appear to indicate that the industry had not yet begun to mature and satisfy consumer demand. VCR production figures are not yet readily available on a nation wide basis.

4.1.2 History of South Korea's Consumer Electronics Industry

South Korea's consumer electronics industry has grown more rapidly than China's, but the two are similar in many ways. South Korea has moved up the value-added ladder over time, beginning with production of relatively labor-intensive and low-technology vacuum tube radio sets, and gradually moving through TVs (first black-and-white, and then color) to relatively technology-intensive VCRs.

The Korean economy has made significant gains in the manufacturing sector as a whole during the post-war period. In 1956 manufacturing accounted for slightly under 8% of GDP; by 1975 that share had grown to more than 28%. Much of the growth came from increases in light manufactures, including consumer electronics.

Table 3

Korean Production of Radios, Televisions, Tape recorders (1965-84)

	Radios	Televisions		Recorders
		Color (thousands)	Black and white	
1965	333			
1966	806			
1967	461			
1968	1,197			
1969	1,242		53	
1970	1,088		114	
1971	1,028		209	
1972	1,858		308	
1973	3,272		816	
1974	3,692		1,164	
1975	4,464	43	1,182	
1976	6,717	55	2,236	
1977	6,404	97	2,893	
1978	4,768	584	4,242	8,704
1979	4,772	422	5,445	10,038
1980	3,972	956	5,863	8,973
1981	5,240	2,246	5,302	9,266
1982	5,925	2,190	3,922	7,281
1983	6,719	3,716	3,925	10,462
1984	7,709	4,305	5,425	15,010

Sources: 1965-84 figures for radios and televisions from BOK Handbook, 1978-84 figures for recorders from the Bank of Korea Statistical Yearbook, p. 149.

Television production started in 1969; within a decade the industry had moved into the production of significant numbers of color television sets. In the ten years from 1969 to 1979, black-and-white set production increased by a factor of 100. Such rapid growth could only support high international sales, most of which were made in the US market.

Tape recorders were first produced in 1970, with an annual production that year of 39,264 units. Output rose rapidly, to 197,977 units in 1971. This pattern continued, especially through the years 1973-75 (see table #3, above), as the industry matured and production capacity was added.

Samsung Electronics initiated Korean participation in the relatively new area of VCR technology when it developed a system for a VHS-format VTR in 1979, making it the fourth country (after the US, the Netherlands, and

Japan) to develop such a system without foreign assistance.[3] However, cooperation with Sony and the Japan Victor Co. (JVC) was required before Samsung, Daewoo, and Gold Star were finally able to produce VCRs commercially in 1982. Export sales by Korean manufacturers were restricted for several years by the Japanese licensors, to allow themselves time to build their market share. Strong VCR sales on the Korean domestic market provided the stimulus for the three firms to move rapidly into production. By 1984, one year before the export ban was to be lifted, VCRs had grown to occupy 25% of all Korean domestic home appliance sales, a significant increase over the 16% figure posted in 1983. By the end of June 1984, the domestic ownership rate had only risen to 4%, far below the 35% rate in the US and Japan and indicative of domestic market demand strength. In response to this perceived domestic and known foreign demand, all three Korean VCR manufacturers have continually increased their production capacity since the early 1980s.

Korean plants have been very responsive to the changing export market situation: they have historically varied their production from product type to product type depending on the relative value-added. One example of this type of enterprise is the Hyup Jin Enterprise, established in 1967 as a garment producer. In 1977 the company moved into consumer electronics production. While not as large as some of the better-known Korean electronics firms, the company has relied on export sales to Europe and the US and appears to have prospered in the highly competitive international market.

4.1.3 History of Japan's Consumer Electronics Industry

Prior to World War II, Japan had already developed a significant technological base in radio production. While the industry's production capacity was destroyed during the war, reorganization under the Ministry of International Trade and Industry (MITI) in the post-war era gave the consumer electronics industry a boost which allowed it to re-emerge rapidly.

Active technology acquisition has given the Japanese a leading position in the production of many consumer electronics products. As early as 1954, Sony had negotiated an agreement with Western Electric for transistor technology. Over the seven year period from 1960 to 1967 Japanese firms negotiated slightly less than 200 licensing agreements with RCA. In 1964 Toshiba was already interested in the acquisition of video tape technology from Ampex.[4] This pattern of continuing technological advancement, combined with inexpensive labor and attention to quality control measures, allowed Japanese consumer electronics firms to grow rapidly and dominate international markets. By 1971, 5 of the top 10 consumer electronics producers in the world were Japanese.[5]

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[3] "VTRs: Korea's Hot New Export Ticket?," Business Korea, February 1985, pp. 25-6.

[4] International Competitiveness in Electronics (Washington, D.C.:U.S. Congress, Office of Technology Assessment, OTA-ISC-200, November 1983). pp. 120-21.

Table 4

Japanese Production of Radios, Televisions, Recorders, and VCRs (1935-82)

	Radios*	Televisions		Recorders	VCRs
		Color	Black and white		
		(thousands)			
1935	154				
1936	427				
1940	853				
1945	88				
1950	287				
1955	1,789		137		
1960	12,851		3,578	477	
1965	22,937	97	4,093	4,954	
1968	30,189	2735	6,405	10,247	
1969	34,090	4834	7,851	18,353	
1970	34,640	6399	7,383	21,391	50
1971	28,091	6872	6,359	22,185	
1972	26,833	8388	5,915	27,524	
1974	21,931	7,323	6,083	30,364	124
1975	16,364	7,473	4,980	26,078	119
1976	19,626	10,531	6,014	41,014	288
1977	19,933	9,632	5,578	40,315	763
1978	18,781	8,549	5,378	39,742	1,471
1979	15,000	9,365	4,871	41,809	2,199
1980	17,000	10,909	5,418	54,238	4,441
1981	16,000	11,630	4,330	60,540	9,498
1982	15,000	11,423	2,475	52,498	13,134
1983	13,000	12,372	1,587	60,990	18,217

Note: *Includes car radios.

Sources: 1935-55 Radio and television figures from the 1963 Bank of Japan Economics Statistics Annual, p. 224; 1955-72 television (c, b/w), and recorder figures from the 1973-74 Japan Statistical Yearbook, pp. 202-03; 1974-78 figures from the 1980 Japan Statistical Yearbook, pp. 194-95; 1979-82 figures from the 1984 Japan Statistical Yearbook, pp. 238-39; and 1983 figures from the 1985 Japan Statistical Yearbook, pp. 239-40. (J6ae04t.c6d)

Japanese electronics manufacturers first incorporated the transistor into their products in 1959, when it was first incorporated into radio design. By 1962, out of a total radio production of over 14 million sets, only 1.3 million continued to use vacuum tubes.[6] 1963 saw the initial production of portable, smaller radio sets, which rapidly overtook console models and helped the Japanese to boost both domestic and international sales. This tremendous boom in radio production and sales helped infuse capital into the consumer electronics industry, which proved to be a major support for the strategy of building long-term market shares as opposed to concern over short-term profits. This strategy allowed the industry to grow in the higher value-added products which followed.

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[5] Ibid., p. 122.

Television production also grew rapidly. Black-and-white production was started in 1955, color in 1964. As early as 1962, the Japanese were miniaturizing their sets, thereby filling a growing niche in the market dominated by large American manufacturers. The 1966 Tokyo Olympics brought about a surge in domestic demand for television sets, and provided the boost that domestic manufacturers needed to gain a solid footing in the industry. Exports grew extremely quickly, eventually forcing the various firms into offshore production arrangements for some of their production. Drawn-out dumping charges in the mid- and late-1970s led to a decline in production, but exports to China drove production up again in the early 1980s.

Production of tape recorders was begun in 1959, and also grew at a rapid rate.

Video tape technology was first refined into a commercially viable product by the Japanese, before the Phillips Co. of the Netherlands developed a system. Victor Company of Japan (JVC) and Sony made significant inroads and standardized their respective formats in the VHS and Betamax systems. Originally too expensive for widespread consumer acceptance, the products were not widely sold until the late 1970s. During the 1970s, the larger Japanese firms spent a great deal of energy and money improving the systems and attempting to reduce production costs. By 1979, costs had finally been reduced to a point where VCRs were commercially viable. Without significant foreign competition, the Japanese firms (now including Hitachi, Sanyo, and Toshiba) grew to hold over 95% of the world market by 1983, a trend that is likely to continue for some time.

Attention to quality control measures by Japanese consumer electronics manufacturers was institutionalized at an early stage, first in the form of quality circles, and later in the Reliability Center for Electronic Components of Japan. The Union of Japanese Scientists and Engineers (JUSE) brought in foreign lecturers to discourse on the importance of quality control, and initiated a program of quality "circles"--groups of blue-collar, clerical, and managerial workers in a given production line who work to improve the quality levels of output. In the early 1970s, the Reliability Center was organized to conduct tests on various aspects of the production processes of electronic products, and to disseminate technology relevant to the industry. In addition, all Japanese exports are now required to carry the approval of the Japanese Institute of Standards.[7]

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[6] Japanese Industry 1963, The Foreign Capital Research Society c/o The Bank of Japan, p. 74.

4.2 Current Technology and Productivity Levels in the Consumer Electronics Industry

At present, China's very large consumer electronics sector is beginning to produce relatively advanced products, but only with the help of imported technology. Japan has been the major supplier of know-how and technological processes to date. China is now able to produce a wide range of advanced products including color televisions, VCRs, and compact discs. Managers in Chinese factories are responding to more discriminating domestic consumer tastes by increasing the quality and sophistication of their products, and are shifting production up the value-added ladder, from monaural radios to AM/FM cassette recorders with detachable speakers, and from black-and-white television sets to color sets. This pattern is very similar to that experienced by the Korean consumer electronics industry several years earlier, and the Japanese sector even earlier.

Both South Korea and Japan have, like China, relied on imports of technology to advance the state of their consumer electronic sectors. This process continues today in Korea, where a somewhat immature electronics industry still relies on significant imports of front-end microelectronic components from Japan, often for re-assembly and re-export. Japan is the undisputed leader in the world consumer electronics industry; domination of the international market in recently developed products (VCRs and compact disc players) is but one measure of its success.

4.2.1 Technology and Productivity in China's Consumer Electronics Industry

China's consumer electronics industry appears to be more mature than is generally perceived in the West. While some factories do continue to incorporate vacuum tube 1960s-level technology into their products, the vast majority of radio and television production is based on transistor and integrated-circuit technology. Imported technology plays a large role in the production of advanced products, such as television sets (color and black-and-white) and portable, miniaturized radios and cassette players. Occasionally, these technology imports are too sophisticated, resulting in a more lengthy process of assimilation and digestion than might otherwise have been expected. Quality control and reliability problems continue to affect the industry, but to a lesser degree than in earlier years.

At the low end of the technology scale, radios offer an indication of the diversity of China's current consumer electronics technology. Electron tubes, transistors, and integrated circuits are all commonly-used production technologies throughout Chinese radio factories. Transistors appear to be the mainstay of the subsector, with most electron tube-based or integrated circuit-based radio factories also producing transistor radios. Many factories produce transistor radios only. Of those firms using integrated circuits in production, some (such as the Changde Prefecture Radio Factory in Hunan Province) are relying on imported technology and some (such as the Guizhou No. 1 Radio Factory in Guiyang, Guizhou Province) use indigenous technology[8]. Transistor radios and IC radios are produced in portable, miniature form and console form, while electron tube units are produced only in console form. The majority of award-winning products (assumed to represent relatively high technology and quality levels) originate in the larger, coastal cities such as Shanghai and Nanjing; however, there appears to be a wide range of technological sophistication throughout the hinterland, as exemplified by the Guizhou factory mentioned above.

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[7] Ibid., pp. 224-5.

Given China's long experience with radio production it is not surprising that this is the product which appears to have moved farthest through the product life cycle. By the early 1980s, quality levels had risen to a point which allowed significant entrance of the product into international markets. Exports of radios to the rest of the world began in the late 1960s, and have grown rapidly over the last decade. Over US$26 million worth entered the US market in 1985. Acceptance in the very competitive US domestic market would appear to signal the arrival of China's radio producers at a high quality level.

Television production, having grown explosively in the early 1980s, is finally beginning to reach a more mature stage. Domestic demand for black-and-white sets is gradually beginning to level out (especially in urban areas), while demand for color sets continues to increase rapidly. Of the more than 16 million television sets produced in 1985, 4 million were color sets. Increasingly, Chinese publications such as Peking's Economic Daily carry editorials about the need for increased quality control and expanded repair facilities for color televisions, an indication that ownership of color sets is becoming more common.[9]

Much of the technology central to China's television industry has been imported. Production technology for black-and-white picture tubes was one of the initial imports; Japanese firms cooperated in 1979 and 1980 with black-and-white television producers in Shanghai and Tianjin on the import of two production lines. Matsushita signed a contract with the Shanghai Bulb Factory for the import of 12- and 14-inch black-and-white picture tube assembly lines. Trial production was expected to begin in 1981. New Nippon contracted for a similar production line, with an annual capacity of 720,000 tubes, in cooperation with the Tianjin Kinescope Factory. Trial production was also expected to begin sometime in 1981. Corning Glass concluded an agreement to import a production line for glass screen production at both sites. Technology imports for the production of black-and-white television sets appear to have ended with these three agreements.

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[8] 2. The China Electronics Industry Phonebook (??), Hongkong, 1983.

[9] See for example, "Drop by to Repair Household Electrical Appliances," by Zhang Lifen, Economic Daily (in Chinese), Peking, April 6, 1985, p. 1.

Color television production technology (for large-scale plants), in contrast, has been almost wholly imported in the form of production lines and licensing agreements. By June of 1985, approximately 40 Chinese plants were involved with Japanese color television manufacturers in technology transfer arrangements. In addition, production lines have been imported from the US, West Germany, and Holland. Many of the production lines are color kinescope lines, or circuitry production lines. These bring China's total number of color TV assembly lines to 118.

One example of imported technology is the Matsushita-Beijing TV Sets Factory. Matsushita transferred a 1,165 meter-long automated production line, capable of producing 150,000 color sets per year. Work efficiency at this model line was 30% higher than anticipated, and the rate of quality-control approved sets was over 98%. It produces sets modelled after Matsushita's 482D 14-inch set, a design supposedly more reliable than China's designs because fewer components are incorporated into the sets.[10]

Xinhua, China's official news service, claims that through the use and dissemination of imported technology such as the Matsushita line the technology level of some of China's consumer electronics products has been raised to late 1970s and early 1980s world levels. There are even claims made that some color sets average more than 15,000 hours of trouble-free operation.[11]

Similar claims are made about audio tape recorders; estimates of average trouble-free operation run between 1,000 and 2,000 hours. Even if these claims are exaggerated, significant gains have been made in the last five years. During this period, only 7% of the assembled recorders were made with imported parts, down from 40%. China has moved from monophonic recorders to various kinds of double cassette stereo recorders with built-in AM and FM radio receivers. 200 different recorder models are currently in production, including trademark differences. Of the 60 factories producing recorders throughout the nation, 10 are designated for magnetic head production and 10 are designated for core production. In two national quality contests, the rate of quality products improved from 72.8% to 94.6%. This increase, based on improvements in reliability, definition of sound, and grades of balance between soprano, alto, and bass, came about in spite of wide movement away from imported cores to domestically produced cores. Quality ratings were higher still--97%--for certain popular brands retailed in urban department stores.[12]

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[10] China Economic News, 20 July 1981, p. 6.

[11] Xinhua, Feb. 12, 1986.

Intertrade has published an account of the Chengdu Radio Plant No. 7, the first plant in China to produce high-quality magnetic heads for audio tape recorders. After importing a production line from Chiko Electrical Machinery Company of Japan capable of turning out 480,000 cassette recorder heads each month, the plant became the major domestic supplier of magnetic heads, and became the first supplier to sell back to Japan its own products. In 1983 the plant had a total output of 5.24 million magnetic heads. Apparently, the plant's magnetic heads are exported to Japan, Southeast Asia, Europe and the United States; magnetic heads sold back to Japan are then used in medium and high class Sanyo, Kafu, and Matsushita recorders. This plant is credited with allowing the Chinese electronics industry to leapfrog past the production technology development stage, and invest directly in quality control measures and technological improvements.

China's video-cassette recorder (VCR) industry is still in its infancy. The first production line appears to have gone into operation in November of 1985, in Wenzhou. Japan's Orion Co. transferred a production line to the Wenzhou General Broadcast and Telecommunication Factory, and production levels are expected to reach 3,500 recorders per month. Matsushita is also moving into this area; they have agreed to ship assembly kits to China for knock-down assembly, using Japanese-made recording heads. Matsushita's partner is the Peking Television Equipment Agency. Production is destined for the Chinese market only, and the machines will not bear the Matsushita trademark. Recently, Xue Yongshou, general engineer of the Bureau of Radio and Television Industry under the Ministry of Electronics Industry, noted that China plans to continue to selectively import technology with which to develop an indigenous VCR industry. Production lines with an annual capacity of 120,000 to 150,000 video recorders and 250,000 magnetic video heads are to be imported, and Xue stated that foreign partner organizations would be selected on the basis of the "depth and integrity" of technology transfer.[13]

Compact disc players are another new product in China's consumer electronics industry. Shanghai City Broadcasting has concluded a licensing agreement with Victor Company of Japan (JVC) to manufacture the players. Production, planned initially at several hundred units per month, was to begin in late 1985.

All of these products rely to a degree on shared components; electron tubes, transistors, and integrated circuits. While some of the electron tubes used in the various electronic goods are still highly evacuated tubes

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[12] "China's Recorder Market," by Wan Guisheng, China Market, No. 12, 1985.

[13] "China decides to import video making equipment," by Zhang Lin, China Daily, April 11, 1986, p. 2.

(vacuum capacitators, vacuum switch tubes, and vacuum contactors), work with advanced laser technology and other areas of electronics appears to have been widely disseminated and incorporated into a number of products in this category (digital tubes, fluorescent tubes, phototubes, cermet transmitting tubes, pulse magnetrons, klystrons, thyratrons, plasma displays, electro-vacuum ceramic devices).[14] In the area of transistor technology, the Chinese again appear to have made technological advances. At present extensive production facilities exist, and are producing silicon rectifier diodes, silicon damping diodes, silicon NPN planar transistors, germanium low-frequency power triodes, gallium arsenide bulk effect diodes, silicon triodes, epoxy-packaged fluorescent diodes, Schottky switch diodes, junction field effect transistors, microwave transistors, and high-speed switch transistors. Integrated circuit technology also appears to be highly heterogenous. In 1983, Chinese circuit production included HTL highly-antijamming digital ICs, TTL ICs, STTL ICs, HTL ICs, PMOS ICs, NMOS ICs, CMOS ICs, linear ICs, digital ICs, thick and thin film ICs, super-high-speed ECL digital ICs, interface circuits, and TV circuits.

Production capacity for many of these components is imported. Indigenous technology levels of some of the more advanced components mentioned above are close to state of the art, but this situation generally exists in research and development facilities only. One area of difficulty for the Chinese consumer electronics industry is its inability to produce large quantities of high quality components. Because of this problem, export-quality goods often require the import of parts or production processes. Fluctuations in the world supply and price of integrated circuits (for example), then, will prove to be an important factor in the prices of advanced products. Among the production lines imported are two metallic film electrical resistor production lines from Japan, two diode production lines (one from Japan and one from the US), a carbon potentiometer project, and a linear integrated circuit production system.

Unfortunately, there appear to be no reports by Western electronics specialists detailing the actual abilities of the Chinese to incorporate the above technologies into radios, televisions, tape recorders, and VCRs. This lack has forced the author(s) to rely heavily upon information available in the Chinese media, information which occasionally is over-optimistic in its assessment of Chinese industrial advances.

4.2.2 Technology and Productivity in South Korea's Consumer Electronics Industry

South Korea's consumer electronics industry is in many ways immature, but has attained technology and productivity levels which have allowed it to become an important exporter, both to the US and to other areas of the world. Many of the electronic goods produced rely on imported parts or front-end micro-electronics.

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[14] China Electronics Industry Phonebook, Hongkong, 1983. All of the various components mentioned here are taken from their respective sections in this early 1980s vintage source. See pp. 99-119, 125-30, 185-208.

Radio production is relatively low in value terms: approximately 35 million US$. Exports of radios to the US are almost nonexistent. The Koreans have moved ahead in the area of combination radio-cassette recorders, however, and appear to be producing relatively advanced products in this area. Korean manufacturers have moved this product line up the value-added ladder, producing high quality, sophisticated models which remain price-competitive with the Japanese in export markets because of inexpensive Korean labor. These models emphasize stereo sound (as opposed to monaural sound), and have many added functions. Usually they incorporate extra features such as short-wave receivers, double cassette decks, record players, high-speed dubbing, and high-quality detachable mini speakers. An example of a typical model would be an AM-FM-SW radio receiver with dual cassette deck, built-in condenser microphone, detachable 1.8W per channel speakers. Wow and flutter average 0.35 WRMS, and the radio recorder would be able to use 110 or 220V AC 60/50Hz power sources. Many of the Korean companies producing this important export product, such as Samsung, Gold Star, and Daewoo Electronics, rely on buyer suggestions or technical assistance from Japanese companies such as Toshiba for their technical and design innovations.[15]

Television production in South Korea, after experiencing rapid growth for several years, has remained stagnant since 1984, when the industry was hit very hard by US dumping charges. Exports of color televisions to the US have ceased to expand. Surprisingly, exports of black-and-white sets to the US climbed more than 35% in 1984. Current technological developments should allow the industry to recover from the slump in color televisions. Daewoo has developed the Phase Alternation by Line (PAL) system used in almost every country except the US. (The US uses the National Television System Committee (NTSC) system.)[16] As with radio-cassette recorders, Korean television sets are technologically advanced and attain quality levels similar to those set by Japanese products, at a lower price. Much of the advanced electronics incorporated into Korean sets is imported from Japan, and reassembled for reexport.

Koreans are very positive about their current position in the VCR production and export battle. In March of 1985, JVC's export ban on Samsung- and Gold Star-produced VCRs ended; Sony's restrictions on Daewoo's exports had been lifted at an earlier date. Increases in production capacity over the past two years has given the three producers an annual output of 2.12 million sets. All have received the Underwriters' Laboratory

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[15] Charles Sohng, "Korean radio-cassette makers move up with emphasis on value-added models," Journal of the Asia Electronics Union, Tokyo, Japan, May 1985, pp. 46-50.

[16] "TV Makers Look for New Tack," Business Korea, February 1985, pp. 23-5.

(UL) mark for their VCRs. While the Koreans produce many of the components incorporated into the final product (such as headdrums), they rely heavily on imports of higher-technology parts from Japan. Commented one Daewoo official, "...they still have to turn to Japan for such critical components as precision recording heads and integrated circuits (ICs) which make up as much as 40% of a VTR's value."[17]

VCRs are one area of the consumer electronics field where the Koreans have not been able to establish a reputation for quality levels on par with the Japanese. US retailers are pushing Korean manufacturers to market lower-priced models, while the Koreans want to offer more features, such as wireless remote control, slow motion playback, front loading, 8 mm sizes, and digital high-fidelity VTRs. Each of the three has developed a number of models for export (Samsung has 7, Gold Star 11, Daewoo 5), incorporating various of these features. At present the Korean consumer electronics industry is caught between its reliance on Japanese suppliers and its desire to compete with those same companies in the higher value-added end of the market.

4.2.3 Technology and Productivity in Japan's Consumer Electronics Industry

The Japanese are clearly the current leaders in the world consumer electronics industry; they are by far the most technologically advanced and the most productive. While labor costs are higher than those in other Asian countries, quality levels and consumer acceptance allows the Japanese manufacturers to remain very competitive.

Japanese firms have for the most part moved out of low value-added items, such as radios and black-and-white televisions, preferring instead color televisions, radio-cassette recorders, and VCRs. Matsushita, Hitachi, Sony, Toshiba, and Sanyo continue to dominate the industry both domestically and internationally.

4.3 China's Export Potential in the Consumer Electronics Industry

Two factors delimit China's export potential in the consumer electronics industry: the rate of absorption of imported technology, and the ability of the Chinese government to balance domestic consumption of high quality electronic goods and desired foreign exchange earnings. (The latter factor will be addressed below in Chapter 7.) China has already begun to export significant numbers of radios to countries throughout the world, including the OECD countries. Technology exports relevant to color TV production have been initiated to Bangladesh and Madagascar. It is even reported that an initial lot of 1,000 color television sets has been shipped to Finland and passed quality control tests, allowing the sets to be sold on the Finnish market.[18]

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[17] Lee Dong-Geun, "VTRs: Korea's Hot New Export Ticket?," Business Korea, February 1985, pp. 25-6.

Historic observation has shown the ability of a nation to enter into a market by offering price-competitive products in the low end of price and quality ranges for a given product. After using this method to build market share, the country's industry is able to gradually increase the technical level of its production processes. If the cost of labor is competitive, it is able to grab an ever-larger market share. Whether or not China will be able to gain this low-end export base in OECD markets (assumed to be the only markets able to absorb another import invasion in the consumer electronics sector) in the short-term is questionable. It seems highly likely, however, that based on its accumulation of managerial and technical expertise in the industry, China will exhibit considerable export potential in the intermediate- and long-term. It also appears likely that China's growth in consumer electronic exports, especially to the US and European economies, will come at the expense of other Asian Newly Industrialized Countries (NICs), including South Korea. The degree to which Chinese exports will displace Korean and other nation's exports will depend on the relative speeds with which the various countries move up the value-added ladder in consumer electronics.

4.4 Quantitative Prospects for China's Consumer Electronics Exports

Just as for clothing, it is possible to speculate about the significance of technology transfer for China's consumer electronics. As in the case for clothing, we can use statistics from the quantitative analysis in Chapter 6, below, to present some illustrative estimates of export levels to the U.S. under assumptions of high and low technology transfer.

Unlike the clothing industry, China's electronics industry in 1985 had virtually no exports to the United States. If we focus on just three products--radios, televisions (both color and black and white), and tape recorders (both audio and video)--only radios were sold to the U.S. in significant quantities, and they then captured only 1.4 percent of the market ("the market" here and below means the combined Chinese, South Korean, and Japanese market in the United States).

With low technology transfer by the end of the century, judging by the success of South Korea by 1985, China could hold possibly 10 percent of the radio market, 15 percent of the television market, but only 2 percent of the tape recorder market. If the market grows roughly 2 percent a year (4 percent for tape recorders), then China's total sales for these three products could increase from 27 million dollars in 1985 to 670 million dollars (constant 1985 dollars) in the year 2000. The results in terms of export earnings would be more than for the clothing exports because of the much larger size of the overall market, which also means that if technology transfer were more successful, the impact on dollar earnings could be dramatic.

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[18] In China Market, a Chinese publication, it was reported that "The Mudan (Peony) brand colour TV sets, produced by the Beijing TV Sets Factory, have entered the Finland market after a strict quality check by the Finland authorities. In November 1985, the China National Electronics Import and Export Corporation signed a contract on export [sic] of 1,000 Mudan Colour TV sets to Finland." No other available sources confirmed this report. See China Market, No. 2, 1986.

Again, judging from the position of Korea in 1985, high technology transfer could mean that by the year 2000 China will have captured 35 percent of the radio and TV markets and possibly 8 percent of the tape recorder market. Under these circumstances, export sales for the three product categories would increase from 27 million dollars in 1985 to over 2 billion dollars (constant 1985 dollars) by the year 2000. This would be a significant contribution to China's foreign exchange revenues, signaling that even larger earnings are possible when sales to other OECD and third world markets are considered.

In sum, China's export revenues from consumer electronics by the end of the century could be very sensitive to success in technology transfer, so much so that the difference between successful and unsuccessful transfer could be 1.3 billion dollars in sales of just three product categories to the U.S. alone.

CHAPTER FIVE

THE MOTOR VEHICLE INDUSTRY

China's motor vehicle industry since its earliest years has been dependent almost totally on imported technology and suffers most seriously from the lack of an industrial base able to supply the quality steel, glass and parts needed for a truly indigenous productive capacity. In this respect, the Chinese industry resembles that of Japan in the 1930s or earlier, and mirrors South Korea's early dependence on imported components. Productivity is extremely low, not only when compared to the heavily computerized Japanese industry, but also relative to South Korean plants, which themselves suffer from a small scale of production, the result in part of Korea's small domestic market. As a result of China's own very poor technology base for motor vehicles and the virtually complete dependence on imported knockdown kits and parts for the production of vehicles of even moderate quality, many observers see no chance for China to become a motor vehicle exporter by the end of the century. Nevertheless, the size of the Chinese domestic market and the very clear demand for large numbers of foreign automobiles indicate a high probability that first import substitution production and then export of low-cost basic vehicles could develop relatively rapidly, even by the year 2000.

5.1 Historical Growth Patterns of the Motor Vehicle Industry

China's motor vehicle industry began its development in the 1950s, and although it is much newer than Japan's, which dates from the 1930s, it has a longer tradition than Korea's and has developed an indigenous base. Like Japan in the 1940s and 50s, China is relying on domestic market protectionism and technology transfer to overcome its backward technology and to eventually enter a mature world market. Korea did not have an indigenous base and was forced to constrict itself by licensing agreements in order to obtain any technology at all at a much later date in its overall economic development. The potential speed of development depends largely on China's ability to obtain and absorb technology. Thus far, China has been disappointed in the amount of technology foreign firms have been willing to provide. For example, discussions with a Japanese firms for a joint venture to produce passenger cars in China fell through reportedly because the Japanese were not offering to produce a recent enough model car. In addition, in the A.M.C. jeep venture the Chinese were disappointed with the technology transfer rate. The rate of development also depends on the same factors limiting growth in other sectors, although they may be more important to the complex automotive sector. These include China's ability to centralize production to attain sufficient scale of production and ability to strengthen infrastructure to supply parts to assemblers.

5.1.1 History of China's Motor Vehicle Industry

The Chinese automotive vehicle industry, dependent from the very start on imported technology, has failed to develop a significant indigenous productive capacity for vehicles of even moderate quality, and the most recent modernization efforts reemphasize China's continued dependence on foreign model design, production techniques, and basic parts and materials. In addition to the slow development of technical levels and an overall low output level, much of the Chinese industry has evolved as a collection of splinter production facilities, very few of which (if any) have any promise as modern internationally competitive plants.

No serial production capacity for motor vehicles existed in China prior to the early 1950s when, with Soviet help, China established its first integrated automotive production facility in Changchun, Jilin. During the next few years facilities were added in Nanjing, Peking, Jinan, Wuhan, and Guangzhou. After the Soviet departure in 1960, small production and assembly facilities were added in nearly every province. Since around 1981, China has been trying to rationalize its scattered production pattern, although some of the consolidation slid backwards in 1984-85 when many areas jumped into motor vehicle assembly in search of a quick profit.

Table 1
Automotive Production in China

	Motor Vehicles	of which: Trucks	CIA Estimate of Trucks
	(in Thousand Vehicles)		
1957	7.9		7.5
1962	9.7		8.4
1965	40.5		30.0
1970	87.2		70.0
1975	139.8		133.0
1976	135.2		135.0
1977	125.4		150.0
1978	149.1		
1979	185.7		
1980	222.3		
1981	175.6	108.3	
1982	196.3	121.8	
1983	239.8	137.1	
1984	316.4	181.8	
1985	438.8	na	

SOURCES: Total Automotives from the State Statistical Bureau "1985 Statistical Yearbook," (SSBYB'85) page 340 Trucks - 1983, 1984 from SSBYB'85 page 352. 1981, 1982 from SSBYB'83 page 256. 1980 from SSBYB'81, page 234
CIA Truck Production from Bureau of East-West Trade, US Commerce Department.

The motor vehicle industry in China is dominated by trucks as is evident from the data in Table 1, which shows annual production figure totals for motor vehicles and trucks. The other salient aspect of China's motor vehicle industry is its resistance to change. In contrast to the international industrial practice of introducing new models every 8-10 years, the P.R.C.'s auto factories have developed few new models. The mainstays of the industry remained virtually unchanged from the late 1950s until the early 1980s despite increases in output volume. Truck models are also limited in number and functional capabilities. The 3-4 ton Liberation Brand truck accounts for about 80 percent of total truck output. As of 1984, approximately 80 percent of China's trucks were produced in one of three plants: the No. 1 Truck Plant in Changchun, Jilin, the No.2 Truck Plant in Shiyan, Hubei, and the Jinan Truck Factory in Shandong Province. The history of the Changchun No.1 Automotive Plant is important in itself as the first center for China's motor vehicle production. It can also be used to illustrate the more general pattern of development in the industry nationwide, with the early influence of Soviet technology followed by two decades of near stagnant technological development. The Changchun plant was built from 1952 to 1957 to produce a truck given the name "Jiefang," or Liberation. The truck was modeled after a 1940s vintage Soviet truck, which in turn was a copy of an American design from the 1930s. The plant was constructed with Soviet technology, machinery, and expertise. In addition to producing the Jiefang truck for which it was designed, this plant began making passenger vehicles of its own design in 1957. Among these was what became a top-of-the-line sedan, the Red Flag model using mostly imported parts. An improved Red Flag model was introduced in 1966 with a new "V" type engine and a refined body.

The only changes introduced in the 1960s and 70s were based on indigenous technology due to China's isolation during this period. During this time, the plant replaced some of the original Soviet machinery with machinery of its own design. For example, the Soviet box-type gas furnace for heating forging was replaced with a rotating furnace designed and made by the plant. During the same period, an automatic polishing machine was made at the car works, ending hand-polishing of electroplated parts. [1]

In 1981 the second generation of Jiefang CA141 trucks were trial-produced with 5-, 6- and 9-ton models and gasoline engines. In January 1983, the plant began producing Jiefang CA15 5-ton trucks with increased fuel efficiency and more power. These took the place of the 4-and 4.5-ton trucks based on Soviet models from the 1940s, which consumed 20 percent more oil than comparable vehicles from other countries. As of 1983 the plant had an annual capacity of 70,000 vehicles.

The No.2 Plant in Shiyan, Hubei Province, produces 5-ton trucks and 2.5-ton heavy duty vehicles of several variations. It has an annual capacity of 100,000 units and was producing 80,000 units per year in the early 1980s. Its history illustrates another path of development also prevalent in China, particularly in facilities created in the 1960s and early 70s: namely, one based more on indigenous technology. During this time the Chinese produced most of their own plant equipment, although some of it was based on items in use abroad. Similarly, whatever design changes were made in their vehicles were developed domestically, although again they were based on models already on the market elsewhere.

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[1] "Business China" June 29, 1983

In contrast to the No.1 Plant, 98 percent of the No.2 Plant's 20,000 pieces of equipment were made in China when it was built between 1969 and 1971. Designs and ideas of course borrowed from technology available in other countries. For example, the electronically controlled broaching machine used to make cylinder bodies was designed by chief engineer Chen Zutao based on his observations of an American machine in an Italian plant in 1965 and a picture of the machine in an advertisement. The machine he developed combined 10 processes into one, reportedly raising work efficiency tenfold.[2]

By 1978 China had clearly progressed beyond copying foreign designs. For example, original 60- and 100-ton heavy trucks and a 400 ton heavy duty tractor-trailer were being produced. The 400 ton tractor-trailer went into production in 1974 in Hebei Province. However, "the continuing dominance of the market by the Liberation truck means that as a practical matter the level of technology embodied in it is representative of the general level of Chinese automotive technology."[3] The Liberation is heavy in ratio to its payload and uses more oil and gas than current models from Japan or the US; the Commerce Department has estimated that China's truck technology is 20 to 30 years behind the West's or Japan's.

5.1.2 History of South Korea's Motor Vehicle Industry

Korea has been producing automobiles for twenty years and exporting them at a significant level since 1977. As was the case for Japan's auto makers (see section 5.1.3, on Japan's automotive industry history), Korea's auto makers, although fairly new to this product, have experience in similar large scale industries. For example, Hyundai, which has just entered the US car market is the largest corporation in Korea and has decades of experience with major engineering projects such as shipbuilding. Thus, the Korean auto industry has a significant managerial and productive base, more similar to Japan earlier in her automotive development than to China. However, Korea depends on various arrangements for technology sharing or transfer with Japanese and Western automakers for the vast majority of its technology needs, designs and components. For example, the current champion of the industry, the Hyundai Excel, has an Italian-designed shape, Mitsubishi-designed engine, and transaxle, fabrics and tires from America. In addition, due in part to domestic restrictions, high taxes on individual car ownership, and Korea's relatively small size, Korea has not yet developed production capacity large enough to take advantage of some economies of scale and to allow investment in the most modern technology and equipment.

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[2] "China Industry Profile: Automotive, Part 3" in "Business China," July 13, 1983.

[3] 1978, Bureau of East-West Trade, US Commerce Department.

5.1.3 History of Japan's Motor Vehicle Industry

Japan's motor vehicle production predates China's with truck production beginning in the 1930s and car production in the 1940s. China began production of both in the late 1950s, but this fact minimizes the time gap between the two. Japan's industrial base in related industries such as specialized steel, ball bearings, and machine tooling was much more sophisticated in the 1930s than China's was in the 1950s. The state of supporting industries, as well as other ancillary factors such as transport and communication facilities, helped determine the speed of development for the automotive industry in Japan and suggest why China's development has been slower.

Of the eleven firms making motor vehicles in Japan in the early 1980s, all except Honda were manufacturing motorcycles, aircraft, textile machinery or other precision machinery products prior to World War II. Nissan began producing trucks in the 1930s after importing designs, engineers and equipment from the United States. [4] Toyota copied components from American cars around the same time and then moved into small cars in 1945 by disassembling and analyzing several European models. After the war, Nissan, Isuzu and Hino also began to develop small cars of European standards.

In the postwar period Japanese engineers learned to make automobiles in small lots, using strict inventory controls and the precise coordination of parts manufacturing and delivery, subassembly production and final production, and final assembly. The automakers also began forming supply networks with a minimum of direct investment. They established long-term programs to increase productivity and quality, subcontracted components and final assembly at unusually high levels, and invested consistently in machinery and equipment.

The development of Japan's automobile industry was facilitated by a transition from trucks to cars, as opposed to being built from scratch. Volumes were kept relatively low through the 1950s, and companies invested in plant and equipment. Increasing sales in the 1960s and 1970s allowed Nissan, Toyota and others to benefit from "learning curves" and huge economies of scale. In addition, protection from imports kept domestic car prices at artificially high levels until the late 1960s, helping to finance new investment in plant and equipment.

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[4] The Japanese history section is drawn primarily from Chapter 1, pages 1-10 of "The Japanese Automobile Industry: Technology and Management at Nissan and Toyota," Harvard University Press, 1985.

Export sales were very small through the mid 1960s, but were useful for testing the American market through trial and error. The trial period allowed manufacturers to make the necessary design modifications to suit the US market. Brief periods of open markets in the 1920s and again immediately after the Second World War led the Japanese government to adopt protectionist measures, but also to seek technology transfer into Japan. These protectionist measures allowed domestic firms to experiment in the automobile industry and to survive despite the existence of larger and more efficient competitors. During the Occupation of Japan, sales of foreign vehicles drained Japan's foreign currency reserves, leading which leading MITI to impose a value-added tax of 40 percent on cars. This move led to the reduction of imports' market share from 44.6 percent in 1951 to 23.1 percent in 1954 and 8.9 percent in 1955.

China's automobile industry appears to be at a comparable stage to that of Japan when large scale production and industry development began there. China today has the backward technology and low domestic demand that Japan faced. China is also adopting similar policies of technology transfer and domestic market protectionism to catch up in a world market now led by Japan. A recent study on the Japanese automobile industry provides a very useful summary of that subject's history as well as offering a thought-provoking scenario, albeit an optimistic one, of how China's industry may evolve:

> "A venture in the automobile industry during the 1930s seemed to be an almost impossible dream to many businessmen and government officials in Japan, because of American domination of the Japanese and world markets. Yet the founders of Nissan and Toyota persisted; and their late entrance into a mature industry made it possible to learn from older auto-makers in the United States and Europe, and to concentrate more on technology transfer and process innovation rather than new product technologies. At the same time, government protection from foreign competition, along with creativity in the management of technology and people, were equally necessary for success. As the domestic industry grew, the Japanese turned historical disadvantages stemming from the initially backward state of their technology, and the low level of demand for their cars prior to 1960, into competitive advantages in the international marketplace."[5]

5.2 Current Technology and Productivity Levels in the Motor Vehicles Industry

In 1984, Japan produced 11 million passenger cars, Korea produced 160 thousand, and China produced 5 thousand. Japan's level of automation, economies of scale and product sophistication separate the three countries by nearly the same distances. As the three countries' production levels suggest, Japan is a leading contender in a world auto market which Korea is only just now beginning to explore and which China probably won't enter competitively until at least the year 2000.

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[5] Michael Cusumano, The Japanese Automobile Industry. Harvard East Asian Monograpns #122, 1985, p. 374.

5.2.1 Technology and Productivity in China's Motor Vehicles Industry

In 1985 China produced 400,000 vehicles, 70 percent of which were 4-5 ton vehicles. In 1984, 300,000 vehicles were produced, of which only 5,000 were cars. During the Sixth Five Year Plan (1980-85), the value of output from motor vehicles rose an average of 19 percent annually while output volume increased 13.6 per year on average. However, the industry still faces serious challenges. Chen Zutao, president of China Automotive Industry Corporation, stated that there are many small units operating at low-efficiency levels. Other problems he mentioned were poor management, low technological levels, high costs and the irrational structure of enterprises.

Some of the measures being taken to address the industry's shortcomings may or may not be useful to help China become competitive internationally. The measures include: randomly importing technology; rapidly switching enterprises into auto assembly plants; and allowing too many new vehicle models to be produced before extensive service and parts networks are in place. For instance, poor organization has led to a great deal of duplication of technology imports. As Chen Zutao has pointed out, "China has already imported and digested a number of technologies such as paint electrophoresis of the driver's cab, hot-blast dust removal systems, and so on, yet there is still an endless stream of enterprises sending representatives abroad for talks on importing such technologies." In 1984 enterprises in other sectors became involved in vehicle assembly of imported kits, producing very low quality vehicles. A further problem is the introduction of a wide variety of foreign vehicles for production, which will make it difficult to coordinate the supply of spare parts and to provide proper maintenance. As of mid 1985, ten types of light vehicles and five of heavy vehicles fell into this category.

Chen Zutao also noted that during the Seventh Five-Year Plan (1986-90), emphasis will be placed on developing heavy-duty vehicles, light vehicles, and serialized key spare parts by importing technology, technological transformation, and renovation.

China has emphasized and continues to emphasize the development of an indigenous technological base, as is clear from the brief history of the industry given at the start of this chapter. The Chinese need not only to produce international quality motor vehicles, but also to develop the related infrastructure. Currently, China is engaged in reshaping the industry to centralize production, improve parts, and promote improved technological dissemination.

As part of the technical dissemination effort, an automotive research center has been established in affiliation with the No.2 Automotive Plant. The center contains design and technology research institutes and employs more than 3,000 technical experts, many of whom have advanced technical degrees. They are involved chiefly in research and development work, but they also provide on-the-spot consulting for production problems. The center has extensive equipment to test new products, including a computerized road-simulating testing device developed at the center.

Despite the existence of facilities such as the No.2 Automotive Plant Research Center, the industry as a whole remains well behind its international competition. According to one industry account from 1983, "people in the Chinese automotive industry keep fairly up-to-date on what is happening in modern production techniques around the world, but there is a considerable difference between their knowledge and the situation in their factories."[6] Failure to exploit economies of scale has also denied - and continues to deny - China an important source of productivity growth. For example, in 1978 130 enterprises in 26 provinces and under the jurisdiction of several ministries produced 150,000 motor vehicles." [7] The production process in many of these plants is highly labor-intensive; the product often has remained unchanged since its introduction decades ago. This is the case with the classic Chinese vehicle, the Red Flag limousine, a twenty-year-old design built essentially by hand at a rate of 1 or 2 per week.

In 1981 China began a massive drive to revamp the fragmented production system and to centralize planning. However, the consolidation effort suffered a setback when the increased demand for motor vehicles in 1984-85 led to rapid, unplanned expansion in automobile production. Many areas and departments set up their own general automobile plants. In the first quarter of 1985 alone, 25 new plants were opened, bringing the total from 37 in 1982 (after the industry-wide consolidation drive), to over 100 early in 1985. However, "the plants are scattered and engage in duplicate work without any cooperation or coordination, and are unable to reach economic batch output figures." [8] A Chinese official explained that due to the "automobile craze" of 1985, small but complete motor works with low levels of specialization have appeared in many places. This has led to duplication and high prices for inferior products.

Further anecdotal evidence supports charges of low technology assembly. Representatives from the American trade journal "Automotive Industries" observed the Beijing Autoworks in the summer of 1985. Robert Steinseifer, one of the American Motors Corporation executives on the tour, reported passing a table around which several workmen were puttering over some miscellaneous hardware. When asked by another tour member where the production line was, he accurately replied, "You just passed it."

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[6] "Business China" China Industry Profile:Automotive, Part 1, June 8, 1983.

[7] World Bank, China: Long-Term Issues and Options, page 157 and 158.

[8] Mingpao article in 5/28/85 FBIS

According to current plan projections, import substitution from joint venture vehicle production is to play a major role in upgrading, expanding, and modernizing China's motor vehicle production in the next five years, especially for passenger cars and four-wheel trucks. Production joint ventures have started, with Chinese factories assembling parts. Participants envision gradual Chinese control of design, manufacture and assembly, and, finally, the entire production process. (Of course, some firms have no plans for China beyond an assembly point.) At least one of the foreign companies planning to engage in motor vehicle production in China--Daimler-Benz AG--will use equipment from southeast Asia to assemble its now obsolete models. Concurrent with the increased use of local sources for parts and a parallel drop in prices, the Chinese hope to be able to export an increasing portion of the output from these production joint ventures.

Currently the production ventures are all at the first stage, using China primarily as an assembly base for foreign-designed vehicles. Daihatsu of Japan and Peugeot are planning to start assembling vehicles in China shortly, and both American Motors Corporation's (A.M.C.'s) Chinese Cherokee and Volkswagen's Santana car are assembled from imported complete knock down units. China supplies only the radios, seats, tires and rubber parts for the Santana, and a similar low portion of the jeeps' parts. By the end of 1987, the venture is expected to be producing 30,000 Santanas a year and 10,000 Audis, but the company does not expect to consider exporting until "sometime after 1990."

A.M.C. also took over production of the Chinese jeep derived from 1950's Soviet technology. Prior to A.M.C.'s involvement, the Beijing Auto Works was running at one-third capacity because of the difficulty in obtaining parts on time under the state plan. The plant also employed 10,000 people. A.M.C. cut back the work force to 4,000 under their modernization and upgrading plan. In 1985 the jeep plant produced about 750 Cherokees and 21,000 BJ-212s; both have been sold out for some time. [9] In 1986 output will expand to 4,500 units. Eventually the Beijing Jeep Corporation hopes to produce 24,000 Cherokees per annum.

At the A.M.C. Jeep factory in Peking, Americans observe that until China produces lower-cost parts, the prospect of earning foreign exchange through exports is poor. Twenty five percent of the output was planned for export in the Far East. The company is now starting to build a supplier network that eventually will allow 85 percent of the parts to be obtained in China, although it is not anticipated that China will be able to provide steel, which will have to come from Japan. As Chinese content increases, the price of the Cherokee will definitely come down. If the joint venture is able to keep to its schedule despite its considerable foreign exchange problems, Comanche pickup trucks will begin production this fall.

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[9] Automotive Industries, 10/85

Six months after its auspicious start, the A.M.C. project is caught in a quagmire of financial, legal and technical problems. One basic issue is which party is responsible for financing the retooling of local parts production to increase use of local sources and trim costs to make exports possible. The Chinese claim that A.M.C. is to hesitant in transferring its technology. However, since it is unclear who is responsible to pay for the technology, it is likewise unclear whether A.M.C.is not providing it, or China is not purchasing it. Currently, since all the core parts of the vehicles are imported and China wants to increase pressure for import substitution, the Cherokee kits are faced with 50 to 70 percent duty, thus driving up the costs considerably. Also at issue is how the jeeps may be paid for, in non-convertible yuan or foreign exchange. According to a recent report in the New York Times, the Chinese maintain "tney have no obligation to pay any foreign exchange for the Cherokee. They contend it is up to A.M.C. to invest the money for localization - the figure cited is $70 million over seven years - and to wait for the foreign exchange payout that will come with successful exports."[10] A.M.C. will reportedly stop Jeep Cherokee production by mid-June of 1986 "unless it gets additional foreign exchange."[11]

Similarly, the Tianjin Automotive Industrial Corporation will turn out a fuel efficient model of a Daihatsu designed car. The contract allows Tianjin to produce up to 10,000 Daihatsu Charades a year. Daihatsu will supply production equipment and design plans. The Charade uses 4.5 liters of gas per 100 km, one of the lowest fuel ratios in the world. Currently the Tianjin company is assembling Tianjin-Daihatsu vans.

Peugeot's joint venture, upgrading the Canton Automobile Manufacturing Factory to produce a 1.2 ton pickup truck marks the third automobile production joint venture. Production is to begin in 1988, starting with complete knock-downs and gradually increasing local content to 80 to 90 percent by 1990. Output is expected to be 15,000 vehicles per annum for 1988-1990, and increase to 50,000 vehicles annually after that. Under the contract one third of the output will be bought back by Peugeot to pay for their foreign currency investment. [12]

David Cole, director of the Office for the Study of Automotive

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[10] "A.M.C.'s Troubles in China," John F. Burns, The New York Times, April 11, 1986.

[11] Wall Street Journal, 5/12/86, p. 14.

[12] China Economic News, November 11, 1985, page 3.

Transportation at the University of Michigan, believes China is in a good position to skip some steps in its automotive development in part because of its large natural resource base. He believes that the Chinese are very serious about doing so. His department has over 200 scholars from P.R.C. conducting research there, and the General Motors Institute has approximately 30 more.

As part of the restructuring in the automotive sector planned for the next five years, a move towards production of greater numbers of smaller vehicles is planned. Tianjin and Harbin are to be the production centers. "Under the supervision of the Ministry of Aeronautics Industry, the Harbin center has introduced know-how from Japan and will produce vehicles similar to the Suzuki ST-90 series."[13] This is a key project under the Seventh Five Year Plan (1986-90) and is expected to be producing 40,000 cars and 50,000 engines annually by 1987 and 100,000 and 140,000 engines by 1990. In recent years, the auto conglomerate has produced 5,600 small trucks and vans with 80 percent of the parts coming from China. The Jianghuai Automotive Plant in Hefei, Anhui has begun producing a three-ton diesel truck whose parts are interchangeable with those of tractors, making it popular in rural areas.

Labor productivity continues to be low. In Peking an average of 88 man-hours are required to complete a Cherokee, compared to 32 man-hours in Toledo. It is also important to note that although wages in China are very low, foreign companies pay the Chinese government far more than the workers actually receive. For example, American Motors Corporation pays the government an average of 137 dollars per month per worker while the worker receives around 22 dollars per month. This practice is prevalent wherever foreign companies are involved in employing native Chinese, and it is these higher rates that should be used to judge China's competitiveness vis a vis Korea.

5.2.2 Technology and Productivity in South Korea's Motor Vehicles Industry

Despite obvious advantages for Korea due to the wage rate differential between Korea and Japan, Korea is saddled with significant royalty costs because it lacks an independent technology base. Korea also suffers because the volume necessary to take advantage of process automation does not exist. Yet one Korean car model, the Hyundai Excel, appears able to compete well with Japanese and American cars in the low price, small car market and more models from the other two leading manufacturers may be entering the US market as early as 1987. As it builds up production levels, the Korean automotive industry is also emphasizing consolidation of, and increased investment in, parts suppliers. Korea is also pouring a lot of resources at both government and corporate levels into developing a local technology base and getting out from under Japanese technological dominance, in part by sending large numbers of students to places like MIT and Japanese technology institutions.

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[13] China Daily, 4/2/86.

"Industry insiders complain that their workers lack appreciation for quality workmanship, door or hood fit mean little to assembly line employees who have never owned a car. Nonetheless, the labor input is primary in Korean industry as firms are less able to invest in robotics and similar high tech capital."[14] In terms of general comparisons with Japanese models, Road and Track described the Excel as "missing the driving qualities of the best Japanese small cars, though it is only a few years behind current standards, and not a bad car to drive." [15]

Currently, Korea has mostly small firms producing replacement parts according to the original equipment manufacturer's specifications. However, producers making quality components for use by a large firm for original production processes are becoming increasingly important. The parts industry is also developing quickly due to a number of foreign joint ventures and increased domestic investment.

Increasing the volume of the industry is also seen as key to improving the technology. Exports are expected to provide what domestic consumption alone cannot: sufficient demand for efficient economies of scale in production. Although Hyundai is using some robotics in its Pony production and both of the other two leading producers plan to introduce some in their new lines, none of these firms will be engaged in leading edge production in the near future. According to MIT Professor James Womack, every single piece of engine or mechanical bit in the Hyundai Excel is under Japanese license. The Korean producer's advantage is in offering skilled labor at a low cost; fear of China soon dominating the auto industry on the basis of lower wages has already been expressed.

Currently Korea's car ownership is only 23 per 1,000 people, while Japan's is over 200 per 1,000 and the United States' is nearly 600 per 1,000. Despite growth in domestic demand, in 1987 half a million cars will be left for export. Auto exports are widely regarded as a replacement foreign exchange earner for the aging textile and footwear industries.

"Three Korean manufacturers will be making cars by 1987 on a scale that will necessitate successful exports in addition to hearty domestic market growth. The US automobile market is their main export target. In the meantime, attention is concentrated on capacity expansion and its concomitant growing pains."[16]

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[14] State Department Telex, June 1985, p. 1

[15] Road and Track, May, 1986, page 60.

[16] State Department Telex, June 1985, p. 1

5.2.3 Technology and Productivity in Japan's Motor Vehicles Industry

In general, "Japanese manufacturers are moving into a higher value-added marketplace, with gadget stuffed, sophisticated passenger cars...The lower end of the market beckons manufactures of simple, sturdy and relatively cheap cars."[17] The Japanese are aiming at the $12-26,000 car range, which is the fastest-growing segment of the market as well as the range with the biggest profit margins. Thus far the labor cost advantage of Korea and other Asian competitors is basically offset by the level of automation and economies of scale achieved by the major Japanese producers.

Japanese auto makers have also paid close attention to quality control issues, experimenting with different techniques. One method adopted by Toyota in 1963 (and subsequently by other firms) is that of quality control "circles"--groups of production line, managerial, and administrative workers who meet regularly to discuss and address quality control issues. These issues can include quality control procedures, costs and efficiency, safety, equipment maintenance, and morale.

Quality control circles "contributed to the shift toward in-process inspection by reinforcing the training employees received in quality control methods."[18] At Toyota, circles take on quality problems as monthly projects; results are posted on company bulletin boards.

Quality control circles are one example of Japanese contributions in process development, as opposed to product innovation. However, recent developments indicate that Japan will also assume a leadership role in product innovation in the automotive industry (among others). For example, Japan is currently developing alternatives to steel for use in auto and aerospace technology, such as ceramic engines and man-made fiber materials such as Kevlar. Ceramic engines are not only lighter than steel engines but also do not require extensive and bulky cooling systems.

Product innovations are also likely to be affected by Japan's lead in computer-aided design, and the skillful application of robotics and computers to the production process. Nissan introduced fixed-sequence robots in the mid-1960s and programmable robots in 1969. Large-scale use of robots began in 1976, jumping to 85 that year from 50 in 1975. In 1983, there were 1,400 robots in use at Nissan plants, and robots performed "up to 97% of all operations on lines such as body welding."[19] Toyota, on the other hand, did not use computer and robotics technology as extensively as Nissan until the 1980s. Toyota went from several hundred robots in 1978 to 1,300 by the end of 1984.

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[17] Paul Sillitoe, "Rapidly assembling line," Far Eastern Economic Review, October 3, 1985, pp. 68-9. See also, "First now, but losing the edge," by Sillitoe, Goldstein and Manning, FEER, October 3, 1985, pp. 68-71.

[18] Cusumano, p. 351

[19] Ibid.

Computers were first used at Nissan during the 1950s for accounting tasks. In the mid-1960s, computers began to be used for production control. By 1975, a total control system had been developed and the use of computers was extended to all operations.

5.3 China's Export Potential in the Motor Vehicle Industry

The China Automobile Industrial Corporation considers automobile exports "a cardinal matter of strategic significance" for the next five years.[20] Exports will reportedly be used to balance technology imports and to upgrade the level of China's auto industry. Despite the clear official desire for exports, Western industry specialists doubt that significant exports will be possible in the near future. As mentioned earlier, Volkswagen does not see exports starting for at least several years. China's request that Volkswagen find export markets for some of the Santanas "looks more like a long-term wish than a short-term reality."[21] Interestingly, the Chinese were originally negotiating with Japanese makers to upgrade the Shanghai brand cars, but the talks fell through. According to the Far Easter Economic Review, this occurred "because the Japanese refused to provide a design modern enough to be exported."

General Motors' director of program planning for China commented in August of 1985, "I cannot see any possibility this century for external development of the Chinese automobile industry," and it would be a long time before parts made in China would be imported for use by the US car and truck makers.[22] Severe steel shortages already plague the industry, and the gap between the demand for steel and its availability is likely to increase over time, given the official output projections for both industries.

5.4 Quantitative Prospects for China's Motor Vehicle Exports

Just as for consumer electronics, successful technology transfer in the motor vehicle industry would have a significant impact on China's exports to the United States by the year 2000, making the difference between virtually no market share in the case of technology transfer failure and roughly one percent in the case of success.

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[20] Chen Zutao, as quoted in "China Plans to Improve Automobile Products" in Renmin Ribao (Overseas edition), Peking, translated in JPRS, China Report, Economic Affairs, 29 January 1986.

[21] Dennis Phillips, "VW venture gets into first gear," Far Eastern Economic Review, China Report, ?, 1985.

[22] Mary Lee, "More desired than driven in China," Far Eastern Economic Review. October 3, 1985, pp. 72-4.

Looking closely only at passenger cars, trucks, and motor vehicle parts, in the case of poor success in technology transfer to the motor vehicle industry, China would most likely have no car or truck sales and only sales in motor vehicle parts equivalent to 0.5 percent of the market ("the market" here and below means the combined Japanese, South Korean, and Chinese market in the United States). Given some growth in the market between 1985 and 2000 (2 percent a year for cars, 3 percent for trucks and 4 percent for vehicle parts) China's earnings from these three product lines would increase from 1.6 million dollars in 1985 to 17 million in the year 2000, a relatively insignificant amount.

Even with technology transfer success, however, and a hypothetical market capture of 1 percent for passenger cars, .5 percent for trucks and 8 percent for parts, China's combined export revenues for the three would rise from 1.6 million dollars to 616 million, less than a third of the earnings from the three major consumer electronic categories projected at the end of Chapter 4, above. It should be stressed, however, that for China to capture one percent of the joint China, Japan, and South Korea U.S. passenger car market by 2000, remarkable success would have to be achieved in modernizing the industry, unless the exports represented only assembled kits shipped to China from a developed economy, in which case the exported value-added would be very low and the appearance of export success quite deceptive.

It is clear, therefore, that technology transfer would also make a very great difference for exports of motor vehicles and parts, but that because of the very large technology gap in 1985, even a very successful program of technology transfer would result in export levels well below a billion dollars by 2000. The true impact of successful technology transfer would probably not be apparent until 2010 or later.

CHAPTER SIX

RANKING CHINESE, SOUTH KOREAN AND JAPANESE EXPORTS TO THE U.S.

Although histories of individual industries and the development of their technological sophistication can give some idea of the relative production and export prospects for individual commodities, they provide no systematic framework for ranking products and product categories by their technical requirements. Detailed engineering investigations could add to the qualitative description of technical difficulty, but again could provide little basis for comparing technological difficulties in substantially different product groups. An alternative methodology is introduced in this chapter, one which uses actual trade patterns as a criterion for differentiating technology levels for different commodities.

It is particularly significant that the comparisons in this chapter, as well as the three preceding chapters, are with densely populated East Asian market economies rather than centrally planned East European ones. This is a major assumption of the analysis in this chapter, and indeed of the entire study, that China is moving away from the institutions and policies characteristic of the Soviet bloc and towards economic systems found in other East Asian economies.

Analysis of China's future trade potential cannot depend on past Chinese trends because China's experience over the more than 25 years of Maoist control was so very different from what it has been in the brief period since his death. As a result, cross-sectional comparisons with other Asian countries are the best guide to many future economic patterns, and in particular to trade patterns. South Korea was chosen rather than Taiwan, Hong Kong, or even the Philippines because it is larger than Taiwan with a population more closely approaching that of a Chinese province, because it has more in common culturally with China than most Southeast Asian economies, and because it is not already economically linked with China as is Hong Kong. Japan is valuable for comparisons because of its already highly developed industrial sector and its very large size. Together, South Korea's and Japan's economic and trade patterns today can give some idea of China's overall direction in the future. This is the major assumption on which all analysis in this chapter rests.

The methodology assumes that to the degree that a commodity is exported by Japan but not South Korea or China it is technologically advanced and difficult to produce. Similarly, a commodity is technologically unsophisticated to the degree that China controls the largest market share of exports to the United States. This methodology is based on the economic theory that new products or enhanced quality standards require the highly skilled labor or extremely sophisticated capital-intensive production methods available in Japan. Conversely, older products with traditional quality standards can be produced by the low-skilled and capital-poor methods in China.

By ranking commodities from Japan, South Korea, and China according to their market shares of the total export levels from all three countries, this chapter presents a more precise statistical confirmation of the rough rankings in technical backwardness revealed by the individual sector studies in Chapters 3-5, above. Many apparel exports to the United States are already strongly dominated by China, and the next likely area for increased export competitiveness is largely composed of consumer electronics items currently exported by South Korea. Other consumer electronics products and virtually all motor-vehicle-related exports, currently dominated by Japan's exports, will be much slower to reach acceptable levels or output and quality in China.

It should be stressed that this analysis is not an attempt to prove that high technology products come from Japan. The results cannot be taken as proof of the product life cycle hypothesis (see below). If that were the case there would be a strong tautological element to the methodology, in that the analysis assumes that exports to the United States from Japan are advanced and then seems to set about to show that technologically advanced products come from Japan.

The analysis below assumes that the product life cycle hypothesis is correct from the outset, and then uses it to illustrate which detailed commodity groupings can be expected to prove difficult for China to produce and export. The assumptions are only valid in so far that export capabilities for manufactures depend on technology rather than on culture, custom, tastes, economic conditions, access to markets, or other non-technical factors.

6.1 Theoretical foundation: The Product Life Cycle Hypothesis

The methodology used to rank commodities by the technical sophistication of the production processes required has its theoretical foundation in the product life cycle hypothesis, which can be interpreted from two perspectives, one for a given commodity over the span of its historical evolution, the other for a given rapidly developing economy as if faces a universe of technologies to acquire, some older and more easily learned than others.

In its most basic form, the life-cycle hypothesis focuses on standardization of products and production processes. When a product is first invented and developed, its optimal engineering for purposes of satisfying a wide market is only slowly discovered through a trial and error process requiring close contact with and rapid feedback from the target consumers. That is, in its early stages a product is not standardized to a generally accepted optimal design. During this early period, the many changes in design require that much of the work be done by the equivalent of scientists and engineers whose labor is very expensive, making the early product itself quite costly. In the sense of its productive process, then, there is no standardization, and as a result of the high costs of early prototypes and trial models there is the need for a well-to-do market such as that in an advanced economy. Furthermore, the high skill levels and possibly machine tooling required for the early designs favors economies which are already well developed. In short, the lack of standardization in both product and production process almost assure that the only places where young products can be produced is in advanced economies.

As time goes on and more is learned about the product and how to produce it, standardization increases. The more the product is standardized, the less it needs to be close to the consuming population for feedback on questions of design and the less it requires skilled engineers and multipurpose equipment for production. As the product becomes standardized in these two dimensions, it can more easily be produced in less advanced economies. In the extreme, when a product is very old, as in the case of cotton cloth, for example, both the product and the production process are so standardized that it can be produced by labor with very low skill levels and be of a standard quality acceptable in any market in the world, no matter how distant.

In this sense, then, a product's life cycle is from new to old, from experimental to tried-and-true, and from a low to a high degree of standardization. In a different sense, however, rapidly developing economies have a cycle of their own. At low levels of development they can only produce old and highly standardized products with a highly standardized production process. As they develop, however, they are able to produce less standardized products with less standardized means of production requiring greater levels of labor skills. Such countries move up the technology ladder, then, to less standardized and more sophisticated technologies.

This technology ladder for apparel, consumer electronics, and motor vehicles is the focus of the analysis in this chapter. Using the methodology described below, 56 detailed commodity groupings are ranked according to their degree of product and production sophistication, from old standardized commodities on the one hand to new and rapidly evolving products and methods on the other. It should be mentioned, however, that there are other interpretations for this ranking, and some of the potentially important factors are brought up in Chapter 7, below, on non-technological factors important for technology transfer to China. In particular, a country's income level and the size of its internal market are major factors affecting the development of an indigenous production capability in large consumer durables such as automobiles, and as a result, what may appear as a large technology gap in the statistical results may also have important non-technological explanations as well.

6.2 Statistical Methodology

The statistical methodology used to rank the 56 categories of exports is straightforward and is based on a calculation of market shares, with the most advanced technologies assumed to cause a high Japanese share of the market and the least advanced technologies assumed to result in high Chinese shares in the market. All 56 commodity groupings are related to the apparel, electronics, and motor vehicle industries.

For each commodity, 1985 exports to the United States from Japan, South Korea, and China are summed to obtain the total market for exports to the U.S. from these three countries. For each category, each country's exports are then calculated as a share of this total market. For example, of total radio exports from the three countries to the U.S., China's share is 1.4 percent of the market, South Korea's share is 16.2 percent, and Japan's share is 82.4 percent. By this measure, radios are a relatively sophisticated product. For cotton dressing gowns, however, China's share of the market is 53.9 percent, South Korea's is 33.7 percent, and Japan's is 12.4 percent. Cotton dressing gowns, therefore, are a low-technology product.

It is interesting and not altogether surprising that the ranking by Japan's export share is very close to the reverse of the ranking by China's export share. Where there are some inconsistencies, in the few exceptional cases where both China and Japan have export shares larger than South Korea's, additional value judgments were made concerning whether to rank the commodity by the Japanese ordering or the Chinese ordering.

6.3 Results of the Statistical Rankings by Technology Level

The results of the statistical rankings are presented in Table 1 and Diagrams 1-3, below. In the most general terms, apparel commodity categories have the lowest technology, followed by consumer electronics items and finally by motor vehicles and related products, which apparently require the highest levels of technical sophistication.

Within these broad groupings there is a more detailed ranking of specific products. Within the apparel sector, pajamas, cotton dressing gowns, bras and slacks have a lower level of technical sophistication than skirts, gloves, undergarments and suits. Within the consumer electronics sector, light bulbs, radio transmitters and televisions have a lower level of sophistication then electric handtools, audio and video tape recorders, and microphones, speakers and amplifiers. In the motor vehicle category, there is almost no differentiation among products because of the degree to which Japan dominates the whole market. Nevertheless, parts of motorcycles and electrical equipment for engines and vehicles appear to require a somewhat less sophisticated technology than vehicle bodies and complete automotive trucks, although the variations in market share are so small that the rankings should be given very little weight in this case.

In conclusion, the analysis points to a clear future path for China's export development, from simpler apparel to more demanding apparel, from apparel to consumer manufactures, beginning with light bulbs and television sets, and eventually, from consumer electronics to motor vehicle-related industries. But it is important to emphasize that this analysis alone cannot say how fast the progression will be, it can only give a ranking. For estimates of the size of the gap implied, information from the case studies is essential.

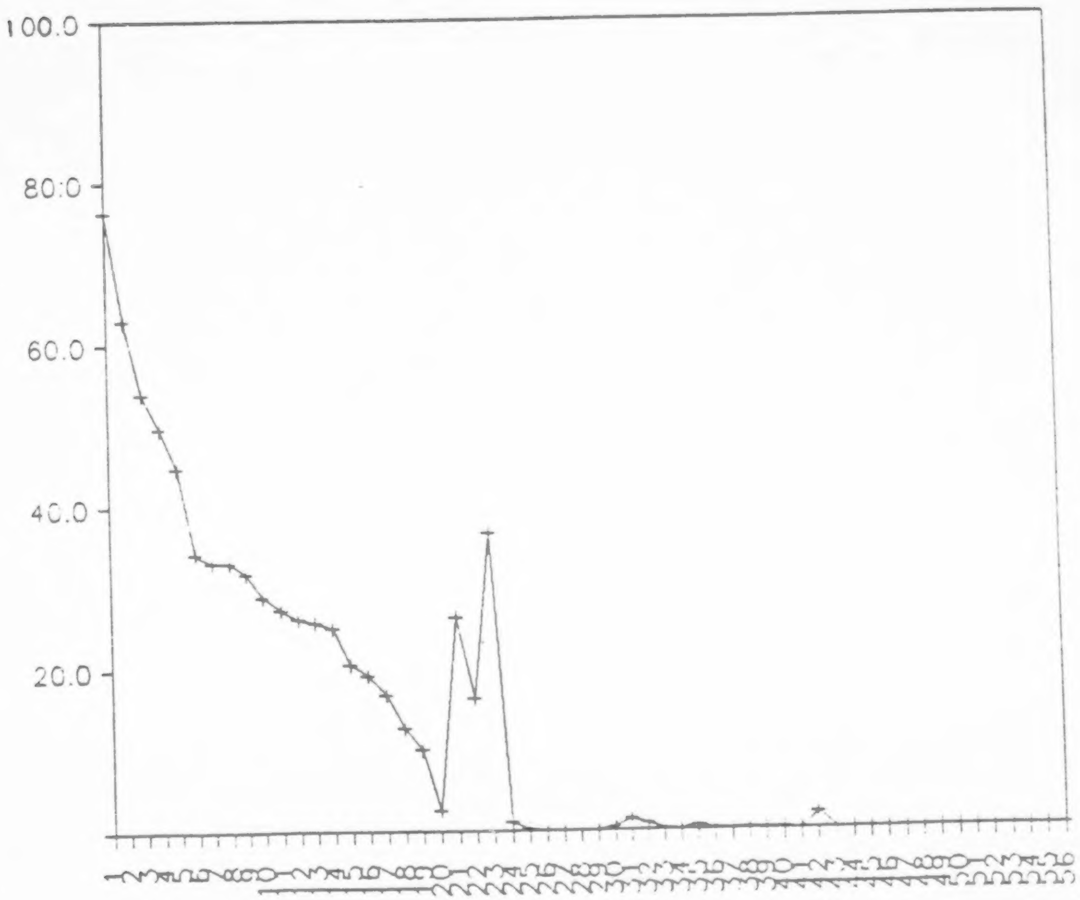
Table 1
A RANKING OF EXPORT CATEGORIES BY LEVEL OF TECHNICAL SOPHISTICATION

United States 1985 Imports of Garments, Consumer Electronics and Motor Vehicles
SCHEDULE A CATEGORIES IN INCREASING TECHNOLOGY

	Schedule A Category		MARKET SHARE IN SELECTED TRADE CATEGORIES		
			China	Korea	Japan
	SITC 7 + SITC 8		100.00	100.00	100.00
	7	Machinery and Transport Equipment	5.28	36.89	89.62
	8	Miscellaneous Manufactured Articles	94.72	63.11	10.38
1	844.2	Pajamas and Other Garments (Men & Boys)	76.31	23.37	.32
2	844.3	Pajamas et al (Women, Girls & Infants)	62.97	29.84	7.19
3	842.8	Cotton Dressing Gowns (MB)	53.92	33.69	12.39
4	846.5	Bras and Other Support Garments	49.60	39.98	10.42
5	842.3	Slacks, Cotton, Wool or MMF	44.75	42.56	12.69
6	843.7	Rainwear Garments	34.20	39.65	26.15
7	846.2	Cotton Knit Shirts (MB)	33.14	34.15	32.71
8	842.7	MMF Dressing Gowns (MB)	33.08	61.77	5.16
9	843.3	Dresses	31.76	63.90	4.34
10	848.4	Headwear	28.91	47.58	23.51
11	842.1	Coats (except suits)	27.32	66.89	5.80
12	843.1	Coats for Women, Girls and Infants (WGI)	26.17	50.47	23.36
13	845.5	Sweaters and Other Knit Outerwear	25.75	68.64	5.61
14	842.4	Suitcoats for Men and Boys (MB)	25.04	60.74	14.22
15	844.1	Non-knit Shirts (MB)	20.57	77.49	1.94
16	842.2	Suits, Wool or Manmade Fibres	19.21	73.23	7.55
17	846.8	Under Garments	16.81	72.51	10.67
18	848.2	Rubber and Plastic Gloves and Apparel	12.71	82.59	4.70
19	848.1	Leather Gloves, Belts and Outerwear	10.08	85.81	4.11
20	848.3	Fur Clothing Except Headwear	2.62	97.03	.35
21	847.2	Knit Gloves, Lingery and Hoisery	26.31	33.89	39.80
22	843.4	Skirts	16.35	36.08	47.57
23	847.1	Handkerchiefs, Scarves, Ties	36.62	9.78	53.59
24	775.8	Electro-Thenic Appliances	1.15	26.44	72.41
25	778.2	Electric Lamps (Bulbs) & Parts	.27	34.14	65.59
26	764.3	Radio Transceivers and Transmitters	.03	25.46	74.51
27	761.0	Television Sets	.03	27.96	72.01
28	776.3	Diodes, Transistors & Semiconductors	.01	34.10	65.89
29	776.4	Integrated Circuits	.00	31.80	68.20
30	773.1	Insulated Electric Conductors (cable)	.40	19.40	80.20
31	762.0	Radios	1.43	16.15	82.43
32	775.7	Electro-Mech Household Appliances	.86	15.64	83.49
33	764.9	Telecommunications Parts	.22	13.06	86.72
34	776.8	Parts of Elec Tubes & Semiconductors	.00	12.17	87.83
35	778.8	Ferrites and Other Mach and Equip.	.58	10.87	88.55
36	764.4	Telephone and Telegraph Equipment & Pts.	.22	8.91	90.88
37	764.2	Microphones, Speakers and Amplifiers	.07	7.07	92.86
38	778.1	Battery & Elect Accumulators & Pts	.21	6.16	93.64
39	772.1	Elect Current Carry Wiring Dev & Pts	.17	6.15	93.67
40	771.2	Non Rotat Elec Power Equip. & Pts.	.13	5.75	94.12
41	772.2	Printed Circuit Boards	.12	5.12	94.76
42	792.9	Parts of Aircraft and Spacecraft	1.98	3.08	94.93
43	763.8	Audio, Video Tape Players and Recorders	.01	4.10	95.89
44	788.0	Other Motor Vehicle Parts	.07	2.29	97.64
45	764.8	Telecommunications Equipment	.03	1.46	98.51
46	772.3	Fixed & Variable Resistors & Pts	.02	1.38	98.60
47	778.3	Elec Equip for Engines & Vehicles	.07	1.24	98.68
48	774.2	X-Ray & Other Radiological Equipment	.03	1.13	98.84
49	785.5	Parts of Motorcycles	.10	.58	99.32
50	763.1	Record Players and Turntables	.04	.29	99.67
51	785.1	Motorcycles	.00	.23	99.77
52	778.4	Electric Handtools and Parts	.05	.05	99.90
53	774.1	Electro-Medical Equip Ex Radiological	.02	.02	99.96
54	781.0	Passenger Motor Vehicles	.00	.03	99.97
55	782.1	Automotive Trucks	.00	.00	99.99
56	784.2	Road Motor Vehicle and Tractor Bodies	.00	.00	100.00

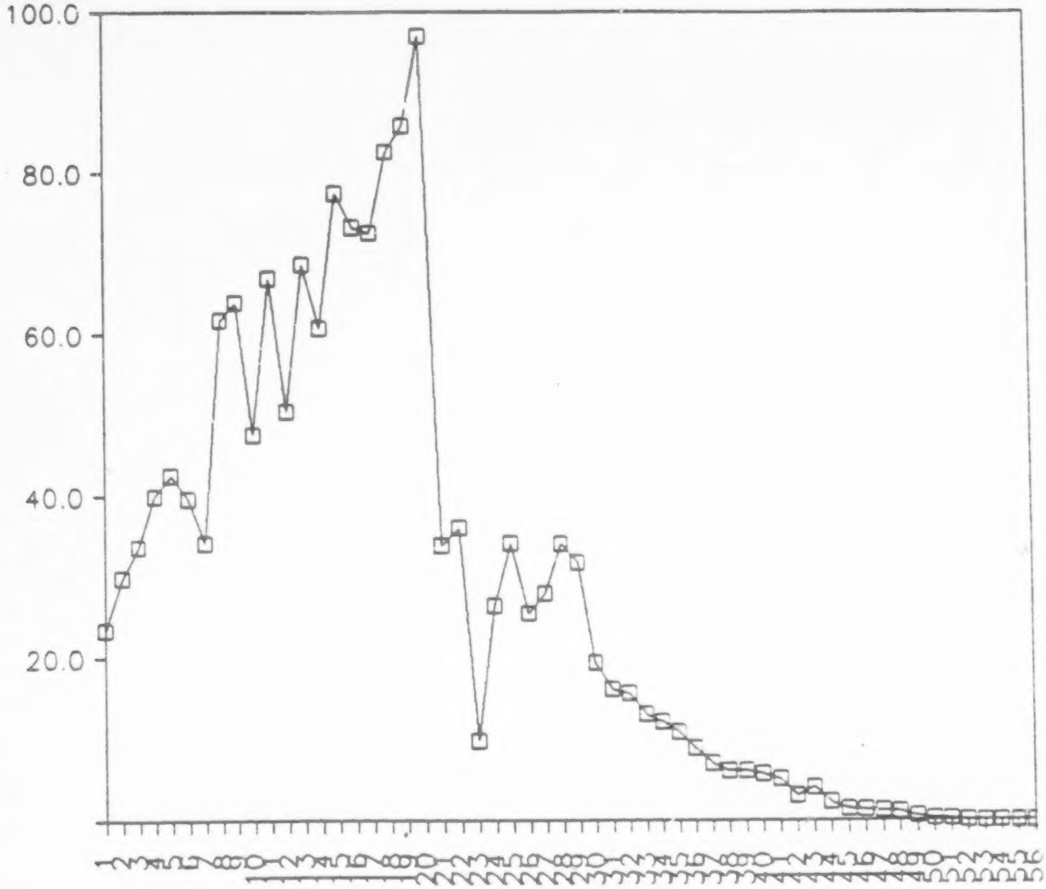
SOURCES: United States Commerce Department, (J6ae10S.d6d)

Diagram 1
A RANKING OF CHINESE EXPORTS BY LEVEL OF TECHNICAL SOPHISTICATION



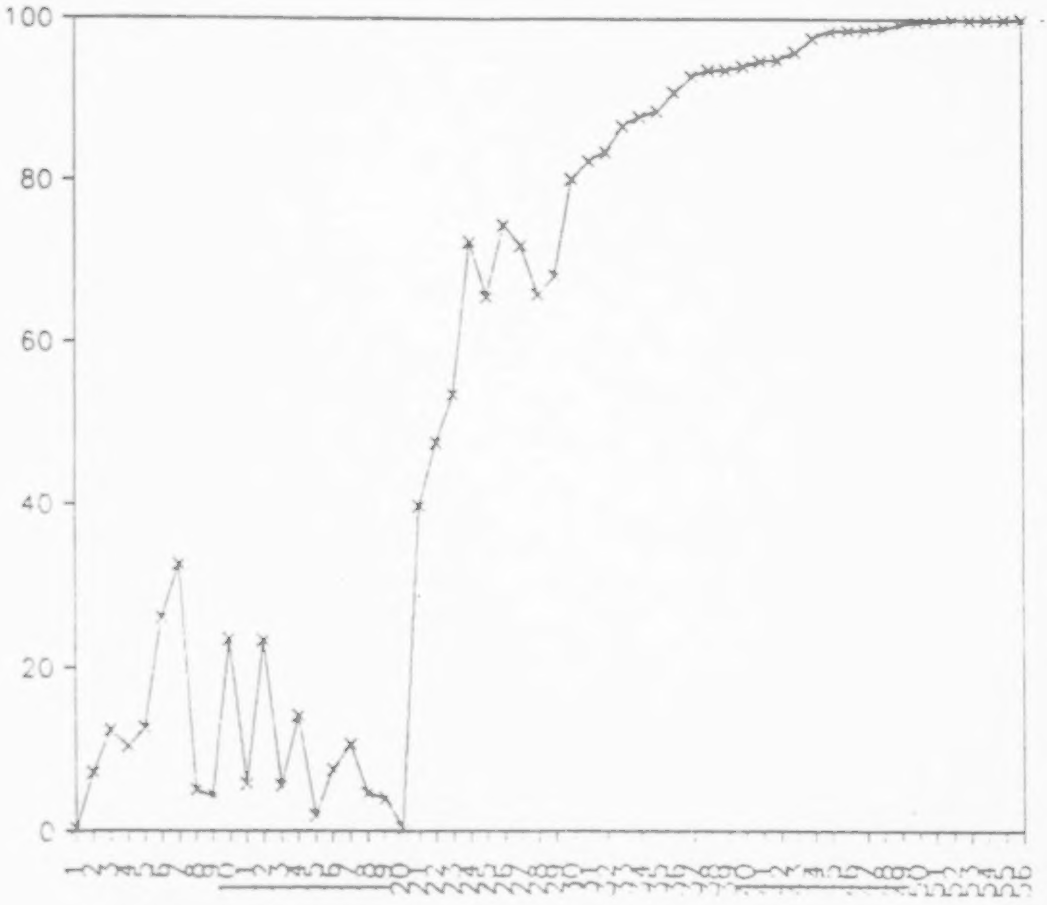
NOTE: The diagram represents China's share of the export market in the U.S. for 56 commodities in the apparel, consumer electronics and motor vehicle sectors from Japan, South Korea, and China, ranked according to hypothetical levels of technical sophistication. For a list of the 56 product categories and the actual market shares for each, see the statistics presented in Table 1, above. For a discussion of the methodology, see the text.

Diagram 2
A RANKING OF SOUTH KOREAN EXPORTS BY LEVEL OF TECHNICAL SOPHISTICATION



NOTE: The diagram represents South Korea's share of the export market in the U.S. for 56 commodities in the apparel, consumer electronics and motor vehicle sectors from Japan, South Korea, and China, ranked according to hypothetical levels of technical sophistication. For a list of the 56 product categories and the actual market shares for each, see the statistics presented in Table 1, above. For a discussion of the methodology, see the text.

Diagram 3
A RANKING OF JAPANESE EXPORTS BY LEVEL OF TECHNICAL SOPHISTICATION



NOTE: The diagram represents Japan's share of the export market in the U.S. for 56 commodities in the apparel, consumer electronics and motor vehicle sectors from Japan, South Korea, and China, ranked according to hypothetical levels of technical sophistication. For a list of the 56 product categories and the actual market shares for each, see the statistics presented in Table 1, above. For a discussion of the methodology, see the text.

CHAPTER 7

NON-TECHNOLOGICAL FACTORS AFFECTING CHINA'S PRODUCTIVITY AND COMPETITIVENESS

Many characteristics of China's society and economy which are not specifically technical in nature nevertheless contribute a great deal to her prospects for improving the productivity and international competitiveness of the apparel, consumer electronics, and motor vehicle industries. In some instances, certain other characteristics have a dampening effect on China's absorptive capacity. Part of the difficulty in assessing non-technical factors affecting technology transfer lies in establishing a standard for comparison. Compared to other East Asian economies, which have already advanced far beyond China's level in numerous dimensions, China's social, cultural, managerial, educational and other endowments are quite poor.

Compared with most other poor countries in the world, however, especially those in Africa, South Asia and even Latin America, prospects for technology transfer to China are enhanced by a wide range of conditions. China's factor endowment, the emerging Chinese economic environment, Chinese leadership at all levels, and certain miscellaneous special factors all act to enhance China's prospects for successfully improving the efficiency of her industries at a pace which will make her a major force in all three world markets if not by the end of the century then most certainly by the year 2010. Reasons for caution in this evaluation do exist but they must be placed in the perspective of prospects in other countries with China's per capita income, and not compared with conditions in industrialized Japan or semi-industrialized Taiwan, South Korea, Hong Kong, and Singapore.

7.1 China's Factor Endowment

Interpreted broadly, China's factor endowment includes labor force, capital stock as it accumulates, and raw materials, including energy supplies. In each of thee categories, China has a strong resource base which contributes significantly to prospects for productivity growth.

Unquestionably the most significant of these factor endowment items is China's labor force. Compared to workers in many third world countries, China's labor force is literate, well disciplined, accustomed to working in large organizations, comfortable with technical tasks, and in generally good health. If there is a contrasting difficulty associated with China's labor force it is the legacy of the Maoist period which left many workers with habits of work which minimize innovation and experimentation because these had been high risk undertakings during the Cultural Revolution with no prospects for reward if successful but almost certain punishments in the case of failure. In general however, the new incentive systems introduced under Deng's reforms are rapidly forcing these attitudes to change. The fact remains that China's labor force is a pool of untapped productivity and this productivity will increasingly surface as reforms and economic development proceed.

Just as in the case of China's labor force, China's capital stock and capital accumulation prospects are the envy of many other poor countries. It is true that from a technical perspective the capital stock is of poor quality, but setting aside consideration of the technological core of China's productive capacity, it also true that productive capacity, of however poor quality, is already in place on an impressive scale. In many cases it will be easier to renovate and upgrade existing plant and equipment than it would be to have to build entire factories from scratch. Similarly, although it is not itself a factor of production, China's high national savings and capital accumulation rate is a national asset and assures a strong flow of domestic resources to the investment and capital upgrading process which most other poor countries cannot generate.

Finally, although a strong base in natural resources, such as for metals and primary energy, is no guarantee that they will be developed and used wisely, they provide the opportunity for fruitful exploitation unavailable to other more poorly endowed economies. Rich in coal and hydroelectric resources, China also has large deposits of many important metals, such as copper and gold. In some cases the resource base is weak, as it is for timber resources, but in general the overall resource availability is impressive by international standards. A cataloguing is not possible here, but together with China's labor and capital resources, the wealth of raw materials helps assure that China's overall productivity growth in the broadest sense of the word will not be constrained by these most fundamental factors.

7.2 The Economic Environment as a Source of Potential Productivity Gain

More important in many ways than China's factor endowment is the economic environment currently emerging in China. This environment includes the economic and legal systems, the overall size of the Chinese market, the transportation network linking different regions in the market, income levels in the population, the distribution of income between richer and poorer households, and the system of information, both statistical and qualitative. In large part because of the effect of reforms instituted under the leadership of Deng Xiaoping, most of these dimensions in China's economic environment now offer considerable promise for productivity gains throughout the economy.

The emerging economic system in China is critical for the growth of productivity and competitive capacity because it vastly increases the choices and substitutes available to various economic actors, whether they be producers, investors or consumers. A growing degree of decision-making discretion is allowed by the enterprise management reforms, the farmland ownership reforms, price reforms in industry and agriculture, financial and banking reforms, reforms in taxation and investment from retained earnings, labor reforms and the many reforms encouraging direct horizontal linkages between economic entities. The freedom to make productive combinations of basic factors and raw materials is much stronger in China today than only a few years ago and promises to continue to improve in the near future to a point where it compares favorably with the degree of discretion available to economic actors in many other poor developing countries.

An even more indirect but nevertheless critical contributor to the strength of the economic system is the strong nationwide legal system and system of justice which is evolving from its very basic form under Mao to a much more complex system more suited to the complex commercial needs of China after Deng's reforms. It is important to stress that China is for all major purposes free from banditry and robbery on the grand scale it is often found in other developing economies. Property rights exist and are protected. Corruption is prosecuted and punished, perhaps with even too much zeal at times given the irreversibility of the death penalty. In short, the legal system in China, even though woefully unsophisticated by American standards, has a strong foundation in the basics which make its future evolution promising. As such, it adds immensely to the importance of the emerging free market environment by helping ensure that its various actors play by the rules of free markets to a significant degree and by adding to the public confidence that market channels can be depended on and used as a basis for investment decisions.

These growing market channels in China are made all the more significant by the very great size of China's market as determined by its institutional boundaries. China is the equivalent of a huge customs union, a duty-free zone with a billion people. While the thought of selling anything to a billion people is not a practical one for foreign suppliers because of the necessary restrictions on foreign exchange repatriation, domestic suppliers face no similar administrative limit to their marketing ambitions.

This very great market size has two important influences on the potential for productivity growth in China. First, it allows economies of scale where they are necessary for the economic production of expensive and specialized items. Automobile production is particularly relevant in this perspective. Second, and in many ways related, the large size of the overall market means that even for exotic items of interest to only a very small fraction of all potential buyers there will be an absolute number of interested buyers large enough to ensure production of many specialized items or items with unusual quality specifications which will also then be available for export on competitive terms. To the degree that specialization enhances productivity and competitive strength, the size of China's domestic market, by allowing high degrees of specialization, greatly enhances China's prospects for productivity growth and competitive quality levels.

It should be added here, however, that the size of China's market is restricted by the inefficiency of the transportation system. For this reason, the advantages provided by such a large market will only be realized gradually and will depend heavily on the success of investments in transportation network by both the state in the form of infrastructure and by individual enterprises and households in the form of vehicles. It is interesting that the effort to tap China's large market through the development of a motor vehicle fleet will itself strengthen the domestic market for motor vehicles and hence the chances for its own growth in productivity.

Although China's very large population promises a large market for many products, the extremely low level of personal income means that no matter how large the number of people one can reach, very few if any will be able to afford a wide range of products which would be demanded in the much more affluent international market. As a result, China's development of such products which appeal to higher income groups in Japan and the west will be retarded. One example of this phenomenon is neckties. Japan's neckties appeal to Western buyers because income levels in Japan have created a market for the expensive ties attractive to Western businessmen. Although more and more Chinese are wearing western suits with ties, styles and materials both appealing and affordable in the United states will have virtually no market in China.

Complementing and complicating the influence of income levels on the extent of China's domestic market for many goods is the pattern of income distribution in post-Mao China, which is very egalitarian by third world standards, due largely to the relatively equal distribution of farmland to peasants. In the first place, the relatively equal income distribution promises to favorably influence the evolution of a large middle class with middle class spending habits. In this sense the income distribution pattern in China enhances the overall contribution of domestic market size to the improvement of productivity and quality levels in a wide range of industries significant for exports. In the second place, the gradual erosion of this income equality at the upper income levels will compensate for the low overall average income level for the whole population. Returning to the necktie example, if enough Chinese businessmen become wealthy, there may in fact be a high-quality necktie market in China well before one would see it in a smaller economy.

Although the various components of China's domestic market are most dramatically represented by the large population and the remarkable series of incentive forms unfolding under Deng Xiaoping, the information network in China also deserves mention. The high literacy level in China mentioned in connection with the labor force description above is relevant, but so is the rapid growth of statistics and statistical information at all levels of the economy and the wide readership of professional and trade journals. On the other hand, the very low level of advertising and the absence or serious weakness of many institutions necessary for a strong advertising industry (private newspapers and broadcasting stations, for example) mean that one of the most basic channels for disseminating commercial information will be ineffective for some time to come, which in turn will weaken the beneficial effect a larger market could have on competition and production. Overall, however, the Chinese propensity to disseminate information and the increasingly productive statistical services have a direct effect on management and decision-making which can only enhance the evolution of better techniques and competitive products. This emphasis on statistical information is being made more complex by the increasing need for sophisticated sampler surveys, but the overall direction of China's information system is towards continual improvement.

7.3 The Leadership Factor in Productivity Growth

Perhaps the most nebulous non-technical factor affecting China's prospects for successfully adopting advanced techniques is the quality of leadership, both at the national level and at the plant management level. By comparison with most other developing economies in the world and certainly by comparison with the quality of economic leadership in Latin America and Africa, China's leadership quality at all levels is extremely high and is arguably the single most important factor for evaluating the true technological prospects.

Leadership at the national level has been responsible for the remarkable series of reforms so critical for the creation of an increasingly competitive and market-oriented economic environment. It seems that the goals of the national leadership are still strongly influenced by the idealism of earlier periods in the history of Chinese communism, an idealism which stressed national development and attention to poverty. At the same time, however, the current national leadership is practical rather than ideological and above all is committed to economic growth. It is this commitment to economic growth which has caused the national leadership to focus on technology transfer from outside China and the indigenous development of science and technology related research. The national leadership is energetically promoting international trade, in particular exports, to earn foreign exchange which are then controlled by the leadership and allocated specifically for the purchase of foreign technology.

It should be added that with the exception of Deng Xiaoping himself, the national leadership is young and has prepared the several secondary and tertiary echelons of even younger leaders for eventual higher positions. In spite of the preparations for transition at Deng's death, however, there is widespread concern that the nature of China's national leadership, so critical for the long-term success of technology development, is unstable. However, while it is impossible to know just how widespread the impact of Deng's death will be, it is fair now, in response to the question, "What will happen when Deng dies?" to say "he didn't." Even if Deng were to die this month, history will record that China was fortunate to have had Deng live so long. It was fortunate that he did not die early in the reform movement. It may be that his continued presence will ensure the success of even more radical reforms, but because he has lived so long already, the general nature of national leadership is highly unlikely to change with his death.

Complementing the high quality leadership at the national level is high quality management and leadership at the enterprise level, especially when judged by third world standards. Chinese managers have a long tradition of running large organizations and managing the flow of information and people that requires. It is true that the current management has had little experience in responding to market conditions and providing the range of leadership needed by enterprises in the new China environment -- marketing and public relations come to mind immediately. Nevertheless, given the high quality of leadership personnel in general, specific management skills are of secondary importance for the success of enterprises and of technology development and adaption.

Finally, relevant for evaluating leadership at all levels is the relatively low level of corruption in China, again by poor-country standards. The current attention paid to corruption is as much a sign of the small scale of the problem, and common experience working in China is that the very large majority of Chinese managers and leaders are honest and dedicated to their work. It is hard to know how long such conditions will last, but a reasonable guess is that they will last at least a generation, and possibly considerably longer. As a result, the high quality leadership as measured in other dimensions and summarized above will continue to play its very supportive and indeed active role in maximizing the development of technology in China.

7.4 Miscellaneous Special Factors Affecting Productivity

In addition to the more fundamental non-technical components relevant for China's future productivity growth, several miscellaneous factors deserve mention in passing. The first is geographical and refers to China's long coastline with many fine harbors on major international shipping routes. China is not nearly so isolated from the worlds commerce as is India or the Soviet Union, to give two major examples. Second is China's special linkages with other Chinese economic regions from which China can learn a great deal and acquire technology and attitudes about productivity and quality levels which would be much more difficult to convey were it not for the language and cultural bonds between China and the business and economic leaders of Hong Kong, Singapore and Taiwan. The relationship with Taiwan offers particular promise, and the longer some normalization is delayed the greater the lost opportunities.

Last in this list of miscellaneous items is the Chinese culture and sense of national identity itself. Because of China's long history as the center of the known world and because of the Chinese perception that their literature, philosophy, and art have no equal in the world, there is a confidence in the minds of Chinese that China can do what it sets its mind to do and that it is only a question of time before China fulfills its modernization mission and once again assumes a position of moral and political leadership in the world. This confident and even self-aggrandizing cultural and historical perspective adds to the quality and determination of the national leadership and to the confidence of management at all levels. It can not be measured. But it is just this confidence that has allowed the national leadership to break so cleanly with the Soviet model and strike out on a pragmatic course to reach China's modernization goals.

7.5 Reasons for Caution in Assessing Technology Transfer Prospects

As mentioned at the outset, the favorable non-technical climate for technology transfer in China is particularly apparent when comparison is made with other very poor economies rather than with other relatively well-to-do economies in East Asia. Never eless, there are many important reasons for caution when considering China technology transfer prospects. For convenience, these can be divi d into five major groupings: weakness in the existing productivity base, po ntial for financial difficulties, labor force problems, incomplete evolution f the market-oriented economic system, and other miscellaneous but nevert less interesting factors.

7.5.1 Weak Productivity Base

Weakness of the existing roductivity base is perhaps the most practical cause for concern for technolo transfer investment projects. The weak productivity base is more than reflection of China's poverty, because it has been exaggerated by the decade of isolation, by the Soviet planning system, and by the dislocations of the adical Cultural Revolution (1966-76). Not only are China's existing prod tion installations based on technologies from the 1950s and even 1930s, Chin 's transportation is seriously underdeveloped; energy shortages are acute, es ecially in the South and especially for electric power; existing techn ogy for parts and other ancillary support sectors is extremely crude whe it exists at all; quality steel, plastics, paper, water supplies and many ther inputs often taken for granted cannot be found easily; and throughout industrial economy small scale of production and antiquated shop layouts m upgrading and renovation difficult. Most if not all of these problems are und in other poor countries, but China's unique history and developmen ath make many of them particularly relevant.

7.5.2 Financial Obstacles to echnology Transfer

Financial difficulties lating to technology transfer really come down to three issues: the availabi ty of domestic funds to support technology absorption, China's foreign e hange earnings from exports to finance foreign technology purchases, and the ase of profit repatriation for foreign firms engaged in foreign technology rojects in China. For each of these areas, domestic funds, export earnin , and profit repatriation, there are significant unknowns with imp tant relevance for the long-term success of technology transfer.

The domestic funding is e refers to future state budget commitments in support of technology transfe and the general level of liquidity growth in the Chinese government. Alth gh increasingly large budget expenditures are being made for technical reno tion, past efforts to balance the budget in the wake of unexpected developmen have relied on cuts in investment, and similar cuts in the future could seri sly slow technology transfer.

The general growth of l uidity in the Chinese economy is a difficult area for analysis, but it des ves mention, nevertheless. Without sufficient liquidity growth, China's dom tic economy will not grow as fast as it might, domestic demand will be const ined, and the attractiveness of transferring foreign technology will be re ced. With the very great increase in commercialization in China an the rapid growth of markets, need for money can be expected to grow much fast than the economy itself. In general this would call for a state budget deficit financed by bank drafts, but China has a very conservative opinion about the role and desirability of state budget deficits, and it is not clear what the official policy will be in the future. There may be other sources of liquidity in the large savings accumulated by both urban and rural residents, because it is not clear to what degree they have already been circulated by the depositing banks and it is even less clear how much of the savings is not placed in banks at all but held in cash. The great power of liquidity expansion to fuel economic growth and foreign technology acquisition was amply demonstrated in the 1984-85 boom, and if efforts to contain inflation by running a state budget surplus also overly constrict growth, technology transfer could suffer.

The problem of export earnings is, of course, central to the financial requirements for technology transfer and needs little elaboration. Two points can be mentioned briefly. First, continued reform of the domestic price system and further devaluation of the yuan with respect to major currencies are both important steps to make exporting more attractive for domestic producers. Second, with the fall in oil prices and the reduction in foreign exchange reserves, China will increasingly seek to obtain access to the markets of those countries from whom technology transfer sales will be made. In other words, China's inability to sell to a certain country on a sufficient scale may make it difficult to source new technology in that country.

The final financial area of concern involves repatriation of profits and hard-currency guarantees for loans to Chinese enterprises buying foreign technology. To the degree that terms and guarantees are considered unattractive by foreign firms lending money to China in the form of direct investment joint ventures, equipment sales on credit, or bank loans, technology transfer will be slowed. China has made some recent conciliatory steps in this direction, but much more remains to be done.

7.5.3 Labor Force Problems

As mentioned above (see Section 7.1), China's labor force is generally literate, well-disciplined, accustomed to working in large organizations, comfortable with technology, and in good health. Several words of caution are nevertheless in order. They relate to the impact of the Cultural Revolution on China's labor force, and the organization of China's industrial economy into enterprise units which, in addition to managing production, also manage employee lifetime benefits.

One potential labor force difficulty is the slow pace of work to which workers in many plants generally became accustomed during the Cultural Revolution. Anecdotal comparisons are often made between older and younger workers which claim that while younger workers are eager to learn and work hard, older workers want the tea breaks and easier pace of the 1960s and 1970s. It is impossible to verify this kind of characterization in a systematic way, and so generalizations need to be made with caution. Nevertheless, to the degree that there is resistance to new methods because of the extra work effort involved, Cultural Revolution habits could hamper technology transfer.

A second lingering impact of the Cultural Revolution is more measurable, however, and encompasses all the eduction and training years lost by youth and young adults while schools were closed and science and technology reviled. Not only does this gap in education and work experience weaken the productive base of the economy directly, it may be a source of unrest and dissatisfaction as middle-aged workers see younger, better-educated staff promoted and given more interesting and lucrative assignments. A large enough cohort of educationally deprived workers could resist the transfer of technology which would give new opportunities to better educated younger colleagues.

A final consideration involves the Maoist system of worker benefits under which most workers were assigned to a unit for life and depended on that unit for all benefits, including retirement pension, health, training, and even employment for children. To the degree that new technologies would require reorganization of units and reassignment of workers, they might be seen as a threat and face more opposition than they would if pensions were national and if labor markets were better developed.

7.5.4 Incomplete Market Economic System

Although reforms in China's economic system have introduced the profit incentives on which technology transfer depends and have in many ways rendered China's economy and society unrecognizable from what they were at the time of Mao's death ten years ago (see above Section 7.2), the reforms are not complete and many elements of the Maoist era will continue to make technology transfer more difficult than it otherwise would be. There are numerous aspects to this topic, but only two will be mentioned below: prices and enterprise management independence.

Although some progress has been made in adjusting China's industrial price structure so that goods are priced according to quality, cost, and general scarcity, many prices are still at unrealistic levels, especially high prices for poor quality or outdated consumer manufactures. The Seventh Five Year Plan (1986-90) envisions continued price reform, but at this stage the unrealistically high prices for many products make them deceptively attractive for Chinese entrepreneurs seeking foreign technology, requiring government restrictions on the importation of useless technology, restrictions which also impede the transfer of needed new equipment and knowhow. At the same time, many much-needed staples and basic industrial goods have been priced low to accommodate urban populations and state enterprises running at a loss. Because of the poor profit prospects in these sectors, it is more difficult to attract investment and leadership for foreign technology projects. In both cases, false price signals could lead to poor investments, failed enterprises, and loss of profits for all partners which would discourage further foreign as well as domestic participation.

Management enterprise independence is perhaps an even more fundamental aspect of the economic reforms because price changes are ultimately motivated by the profit incentives and independent decision-making they imply. But setting aside the influence on price reforms, greater management independence from the control of ministries and local governments will help insure that foreign exchange expenditures for new technology are spent well. As of early 1986, however, enterprise management reforms were only partially carried out, and there were reports in 1985 that local governments had in some cases succeeded in diverting control from ministries to themselves. Although enterprise management independence has been given the highest priority in the new five-year plan, it is also possibly the single most difficult dimension of the urban industrial reforms and while it is incomplete, technology transfer projects and investments could face added bureaucratic interference and administrative delays.

7.5.5 Miscellaneous Factors Qualifying the Potential for Technology Transfer

Two miscellaneous factors slowing technology transfer need to be mentioned quickly: reticence on the part of advanced economies to transfer their technologies to China, and the negative impact on transfer of the sometimes overly difficult bargaining positions adopted by Chinese negotiating teams.

There is serious question as to how much manufacturing technology foreign firms are willing to relinquish to China if that technology will make Chinese goods competitive in finite world markets. Japanese licensing restrictions in Korea have already been noted in the studies on consumer electronics and automotive vehicles. Similarly, while automobile manufactures may be enthusiastic to sell complete vehicle kits to China for domestic assembly, it is not clear how enthusiastic they will be to sell the technology to make the kits. There are other examples, such as chemical processes and computer chip production, and given China's avowed export orientation, many firms could be skeptical of their long-run abilities to enforce any agreement on China's export of price competitive products into existing world markets. It is true that China may eventually find foreign technology suppliers willing to take these risks, but the search may not be easy in some cases and could result in the significant slowing of technology transfer in general.

A second miscellaneous issue is the widely experienced tenacity with which Chinese negotiating teams bargain for price and other concessions, often forcing counterpart teams to return home before believing they have the best offer. To the degree that the bargaining process in China appears too costly and unrewarding to foreign participants, some preferred opportunities may be lost.

CHAPTER 8

CHINA'S TECHNOLOGY GAP IN CLOTHING, ELECTRONICS, AND MOTOR VEHICLES

Before reviewing the details of China's technology gaps in the clothing, consumer electronics, and automotive vehicle industries, it is important to recognize a few general observations. Overall, China's technology gap with Japan and the industrialized West seems to be quite large in terms of basic research and development as well as the ability to produce sophisticated plant and equipment from indigenous resources. This aspect of the technology gap is clearest in China's severe shortage of productive capacity able to produce high quality products on a commercial scale. Apart from issues of output quality and volume, a second major critical dimension of China's productivity gap is the efficient use of intermediate inputs, especially energy. Finally, a third form of technology gap, in labor productivity, is also large but irrelevant for China in the foreseeable future because of the large low-cost labor force. In a discussion of all these forms of technology gap, China's size, labor force, and domestic market require recognition of the important distinction between the token presence of a given technology somewhere on Chinese soil, and firm widespread establishment of that technology in a way that makes China a major domestic supplier and serious competitor in world markets.

Put succinctly, China is such a large country that the token presence of some productive capacity, either imported from abroad or developed in a domestic laboratory, is not a sign that technology transfer has successfully taken place. In an economic sense, and for the country as a whole, successful technology transfer means that productive capacity (and the ability to produce and maintain that productive capacity) has been established on a scale matching the domestic market's scale. This is a difficult element to gauge. In much of the discussion in this report, the presence of a given technology is often interpreted casually to imply successful technology transfer, when in fact the degree of penetration into the dominant indigenous technology is extremely small.

In a more practical sense, however, a distinction must be made between (1) technology transfer guaranteeing quality production on a significant scale on the one hand, and (2) technology transfer which conserves on labor inputs on the other. Some technologies guarantee output quality, others reduce labor costs. China needs the former but not the latter, and so what might be viewed as a technology gap resulting in low labor productivity is for China not a relevant productivity gap at all. Furthermore, this distinction points to important choices for China in acquiring new technology. China must separate out those elements of foreign technology which determine product quality in the core production process from those other elements of the same foreign technology which conserve on labor inputs and which are a response to high wages in advanced industrialized countries. China's technology gap is in the core quality-control technology, not in the labor-saving technology often associated with it.

In the simplest sense, however, China's technology gap refers to the issue of whether China can produce certain categories of goods at all and if so, on what scale and at what quality level. Perhaps most relevant is the question of whether China can produce certain categories of goods of sufficient quality and on a sufficient scale to enable exports at a level comparable to other more advanced East Asian economies.

The information, both qualitative and statistical, presented in Chapters 3-7, above, points to several broad generalizations about the severity of the technology gap in China's clothing, consumer electronics and motor vehicle industries. In briefest terms, there is very little if any gap at all in some apparel categories, roughly a ten-year gap for the more basic consumer electronic items and higher-quality apparel lines, and a 15-20 year gap in technology for sophisticated home electronics products and the basic low-end automotive trucks and passenger vehicles. These "gaps" refer to forward gaps; that is, the estimated time period China needs to acquire the technology to produce commodities of high enough quality and low enough cost to compete successfully in the U.S. market.

The determination of these gaps involves both a ranking of commodity groupings and a determination of the size of the gaps between the ranked groupings. In general, both the statistical rankings determined from Chapter 6 and the more qualitative rankings implied by Chapters 3-5 agree. The specific industry histories and productivity assessments in Chapters 3-5 allow a preliminary estimate of the number of years represented by the various gaps. The non-technological factors encourage some adjustments, particularly for products whose technological development would be speeded up by access to a large and protected domestic market.

8.1 Low Technology Gap Commodity Groups — Apparel

The analysis of 4-digit Schedule A trade statistics presented in Table 1 in Chapter 6 shows that China already has more than 50 percent of the U.S. market for pajamas and cotton dressing gowns, and that together China and South Korea have more than 90 percent of the U.S. market for 20 out of the 22 apparel categories for which the analysis was conducted. At the same time, observations by clothing and textile specialists in China confirm that whether the equipment is imported or locally made, Chinese clothing is of adequate or high quality and is produced extremely cheaply because of the important share of value added due to semi-skilled labor, which is very inexpensive in China. The combination of this information and the generalizations made in Chapter 7 about the large emerging middle class market in China and the very large pool of literate and moderately well-off workers lead to the clear conclusion that China has no gap at all in some apparel, particularly slumber wear, and only a small gap in most other apparel categories.

Furthermore, given the analysis of Korea's apparel industry showing its rapidly rising labor costs, there is even more reason to believe that for many if not most of the product groupings for which China and South Korea share the U.S. market, China will replace South Korea as the dominant supplier by the end of the 1980s.

For specific apparel items, the largest gap appears to be for skirts, a U.S. market still heavily dominated by Japan. The reasons for this dominance are not immediately clear from any of the evidence uncovered thus far. It is also curious that China and Japan split between them the single market category for "handkerchiefs, scarves and ties," which may result from the aggregation problem of having handkerchiefs (possibly a low technology item) and neckties (possibly a high technology item) together in the same category. Without more detailed information, however, there is little basis for such speculations.

8.2 Intermediate Technology Gap Commodity Groups — Consumer Electronics

Intermediate gap commodity groupings are those with a technology difficult for China to acquire for commercial purposes before the early or mid-1990s. Although a few apparel items fit in this grouping (skirts, as mentioned above, for example, and certain hosiery and lingerie items), most of the commodity groupings fitting this gap description are in the consumer electronics sector.

Within the consumer electronics sector, only the most standardized products are likely to have a large share of the market in 1995. The best guide to which consumer electronics products fit in the intermediate gap category is the list of those products at the low end of the product life cycle ladder for South Korea, as shown in Table 1 in Chapter 6. In particular, light bulbs, radios, televisions sets, and radio transceivers and transmitters (walkie-talkies) will be heavily represented by Chinese goods in the U.S. market by the middle of the 1990s. This assessment is in agreement with the analysis of China's consumer electronics industry presented in Chapter 4, which emphasizes the strong base in China for production of radios and televisions.

Certain non-technical factors may adjust this assessment in two ways. First, the Chinese may be able to out-compete Japan and even South Korea for the lowest-cost low-end technology radios and televisions, but they will not be able to compete for features which the Japanese are most able to devise for an ever-dissatisfied American market. For example, split screen televisions and certain kinds of noise reduction for stereo FM receivers may be difficult for China to justify producing for its own market, given low income levels and limited numbers of television channels and sophisticated FM transmissions in China.

Second, a large Chinese domestic demand for video cassette recorders (VCRs) could propel China into production of very inexpensive models with an export potential based on low cost well before a VCR technology capability would be expected from the information in the analysis of the industry in

China, or from the comparative trade data in Chapter 6. The added factor for estimating the VCR gap, in addition to the large size of the Chinese market, is the relative newness of the product and its instant acceptance by markets of all income levels. It is not clear how significant this factor will be. The same factor may influence the early closing of technology gaps in the audio tape recorder market as well. In the early 1980s there is no sign that the government is prepared to underwrite the kind of research and development effort that such an accelerated program would require, so for the time being it is safest to predict that VCRs will stay in the large technology gap category.

Because of the relatively large number of products in the consumer electronics sector, it is possible to illustrate the history of China's technology gap with a diagram showing the introduction or development of indigenous technologies over time for China, South Korea, and Japan. This is done by ranking the products from low to high technology levels and then plotting their development over time. The representation is necessarily crude, but the shape of the resulting diagram, given below as Diagram 1, is nevertheless instructive.

Diagram 8-1
ILLUSTRATIVE TECHNOLOGY GAP OVER TIME: CONSUMER ELECTRONICS

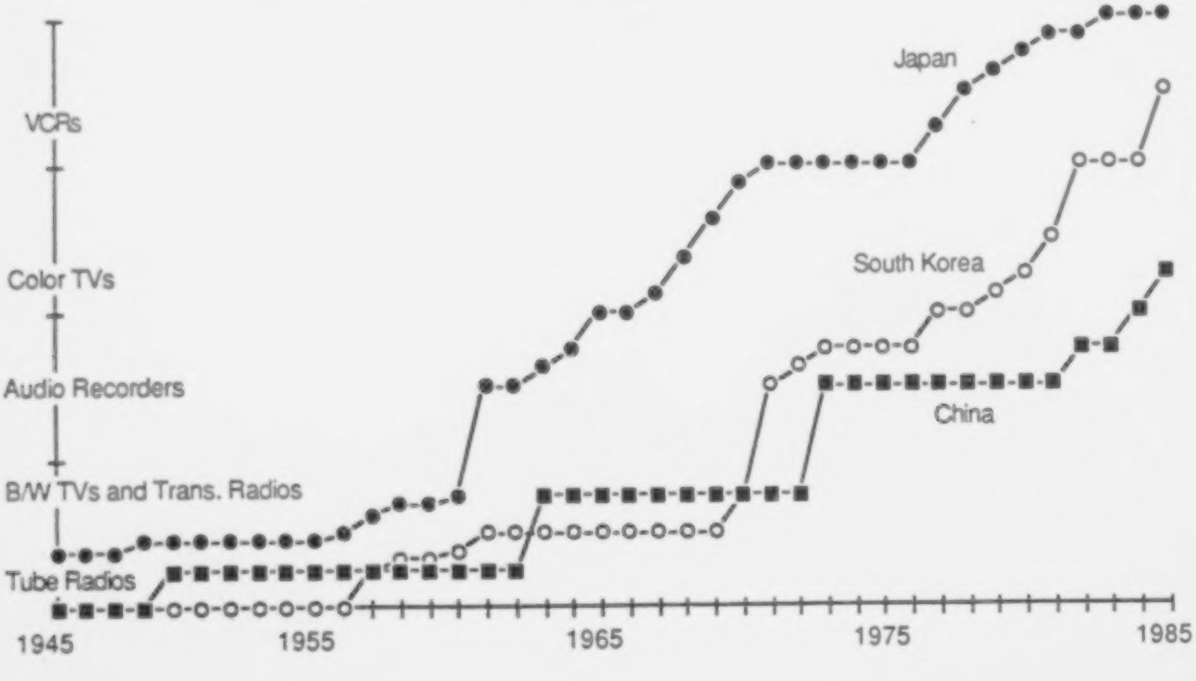


Diagram 8-1, above, has a particularly interesting shape, but it also requires some rather serious qualifications. In general, the start-up of production for a given product was taken as evidence that technology had been transferred or developed, but the shift between levels was smoothed to a minimal degree to reflect Rock Creek Research assumptions about a reasonable period (a few years) for the technology to be brought to significant capacity levels. For details on the development of these individual products, see Chapter 4 on the consumer electronics industry.

With regard to the size of the gaps among the different products, they were set from qualitative rather than quantitative criteria and mean to illustrate only a rough approximation of the difficulty involved in going from one level to the next. The diagram also ignores very important differences in technologies for producing the same product.

In spite of these rather serious qualifications, Diagram 8-1, above, provides a general overview of China's historical technological lag in consumer electronics. The shape of the diagram is interesting, because it represents the inverse of a familiar diagram in population studies used to illustrate the demographic transition. Here, there is a low gap at the start of the post-war period because none of the three economies had high technology production standards by today's measure. Over the period reviewed, Japan opened the technology gap in the 1950s and 1960s, and first Korea and later China began closing it in the late 1970s and early 1980s. It bears repeating, however, that this diagram is for illustrative purposes only and should be used as a supplement to the discussion above and in Chapter 4.

8.3 Large Technology Gap Commodity Groupings -- Motor Vehicles

Just as for the small and intermediate gap product groupings, there is general agreement between the qualitative historical and productivity analysis in Chapters 3-5 and the more statistical analysis of Chapter 6 that there is a large technology gap for certain electronics sub-sectors and for virtually all of the automotive vehicle industry. For the automotive industry, however, the comparison with South Korea becomes much less precise than even that for VCRs. This is because of the small domestic market and late start in South Korea. If the straightforward comparisons with Japan and Korea were valid, it would be the year 2010 before China could hope to have closed the technology gap for low-end inexpensive automobile and truck exports. If China makes a concerted effort in the 1990s to develope a world competitive automobile, the task could be accomplished within a few years of the turn of the century.

The consumer electronics items for which the technology gap is largest are for precision sophisticated products like phonograph turntables, where the quality of components such as bearings and servo-controls is critical for sound quality. In addition, in the highly competitive home sound entertainment market, marketing techniques depend heavily on the "development" of new features which are included in the newest product at no appreciable cost. Keeping up-to-date on these new twists in the "technology" requires a sophisticated market close at hand, one of the original criteria for defining an early product life cycle commodity. This is going to be difficult for

China to develope on any significant scale in the next twenty years.

The large gap in automotive technology is as much a product of industrial infrastructure as it is one of specific automobile or truck technology itself. If China follows the Korean pattern, it may be able to assemble knocked-down vehicles from imported kits on a significant scale by the end of the century and possibly export a few, but it will not become a major actor in the world market until roughly 2010 or 2015. Without a major national effort at automobile import substitution, then, China's lack of quality steels, glass, engines, transmission systems and general construction sophistication will mean that wholly indigenous vehicles will still have poor body integrity, fuel efficiency and safety ratings, preventing entry into the OECD markets.

If, however, China decides to service its rapidly increasing road transportation network with domestically made vehicles capable of traveling safely at speeds envisioned for the new limited-access highways planned and under construction, then the effort to do so could propel China's automobile technology and the supporting industries ahead at a rate much faster than the comparison with Korea would imply. It could be a national project for the 1990s, and it would be an attractive and symbolic target for the 9th Five Year Plan (1996-2000).

CHAPTER 9

ROCK CREEK RESEARCH CHINA MACROECONOMIC MODEL AND PROJECTION RESULTS

This chapter has four parts, a description of the model, descriptions of High and Low scenarios, and a statistical appendix with modeling results. In general, the model has 11 sectors designed to allow analysis of problems relating China's agriculture and industry, China's machinery and consumer manufactures, and China's energy. The core of the model is the measurement of historical trends of capital productivity change, which have been very high in the 1980s, and their projection into the future.

The results of the modeling show that China's economy will almost certainly grow at rates well in excess of official targets and related World Bank projections. Even the Rock Creek Research Low Scenario has gross output of industry and agriculture quintupling by 2000 rather then quadrupling. In the High Scenario this official benchmark increases by more than six-fold, and the related trade projections, especially of manufactured consumer goods and machinery, grow even faster.

The justification for these seemingly high Rock Creek Research projections lies in the weaknesses of the official and World Bank projections and the corresponding strengths of the Rock Creek Research perspective and modeling assumptions. The weaknesses of the official and World Bank baseline assumptions are discussed in greater detail in Chapter 2 and lie in the earlier, lower-growth period on which the projection trends were based, and in the official Chinese need to have targets which could double as political slogans -- whole-number increases are easier to champion, and Chinese officials may have felt quintupling to be a bit too dangerous. Most significantly, however, the World Bank projections did not take into consideration the productivity burst which appeared in 1984-85.

In contrast, the Rock Creek Research projections are based on data through the end of 1985 and explicitly measure and project not only capital accumulation trends but also the trends in the productivity growth of the national capital stock. The Rock Creek Research projections are based on very conservative assumptions about the prospects for capital productivity growth, and yet at even these lowered rates of productivity increase, compared to the early 1980s, result in growth rates very much higher than the official projections. There are direct signs that productivity is increasing, most dramatically in the area of energy conservation. Other, more macroeconomic evidence points to gains for overall growth of as much as 7 percent per year from increased productivity, signifying a broad-based growth potential.

The implication of these introductory remarks is that, if anything, the Rock Creek Research projections are conservative. They appear high only because of the outdated projections with which they are compared, projections which have not fully incorporated the growth lessons China recent economic experience has to teach.

9.1 Description of the Rock Creek Research Model

The Rock Creek Research model is a combination of equations relating assumptions about some future Chinese economic trends to others. The description presented here will be straightforward. For a more philosophical discussion of the modeling methodology in general and the concepts used in this model relative to those of the World Bank and of Professor Lawrence Lau of Stanford University, please see also the discussion in Chapter 2, above.

The review covers five broad characteristics of this particular model. First, the sectors analyzed, variables included, and accounting relationships specified are all intended to allow easy real-world interpretation of all variables, whether they are formally determined by the model or set by the modeler. Second, the production technology used in the model is based on two sources of productivity: capital accumulation and "disembodied" technical change, that is, technical change not related to specific increases in equipment or buildings. Agriculture is a partial exception, and crop output is determined from planted area and value yields for major crop categories.

Third, domestic consumption is composed of investment, final use, and intermediate use, reflecting the model's input-output foundations and the desire to make international trade flows consistent with domestic needs. Fourth, trade is modeled both in real (inflation-corrected) terms and in current dollar terms, in order to address both problems of consistency with the domestic economy and balance of payments issues. Because of the unorthodox domestic price system in China, the linkage between domestic (Yuan)and international (Dollar) flows is based on a set of shadow exchange rates.

Finally, the various trends in the model are reconciled or "closed" through a process of simultaneous inspection by which all projected values are evaluated according to independent information and judgement and adjusted where it is felt necessary. This process is repetitive as different adjustments make others necessary, but certain practical features of the model speed up the process and allow more rapid reconciliation of competing "real world" demands on the model's results, making possible more comprehensive and useful projections than would be the case if the reconciliation process were tedious and difficult to control.

9.1.1 The Model's Accounting Relationships

The sectors, variables, and accounting relationships in the model were chosen to make the modeling process and the model's results easy to interpret. The model has eleven sectors:

Grain

Non-grain foods
Non-food farm products
Processed foods
Consumer Manufactures
Energy
Farm chemicals
Producer machinery
Other heavy industry
Other "productive" sectors
"Non-productive" sectors

The only explanation required for the sectors themselves is for productive and non-productive sectors. In the Marxist national accounting system used by China since the 1950s, activities not directly related to the production and delivery of commodities are "non-productive" and not included in the total measures of national output. However, in Western methods of measuring economic output, such activities are included (for example, health, education, government administration, defense, and housing) and form an important part of GDP (Gross Domestic Product). In order to use official Chinese data and still arrive at estimates for China's GDP, the division shown above must be used.

The sectors differentiate clearly between agriculture and industry, and within industry between consumer goods and investment goods. This allows analysis of the model's results for major household consumption categories, major demands made by investment needs, and trade in politically sensitive categories (grains, energy, and consumer manufactures). In short, with a minimum of complexity the model captures many if not most of the fundamental sectors in the economy.

For each of these sectors, the model describes a range of variables, but the major ones are output, domestic consumption (final and intermediate), and net exports (exports minus imports). Additionally, for each sector there are price trends in yuan and dollars; for all major crop categories (grains, other foods crops, industrial crops, and green manure crops) there are planted area and value-yield trends, with the planted area in turn dependent on trends in total cultivated land and multiple cropping on the same land. For major aggregates (agriculture, industry and productive and non-productive sectors) there are value added flows by sector of origin. There are trends for urban and rural fertility, mortality and crude growth, as well as rural-urban migration, and the resulting population trends generate per-capita results in the model. Current-priced trade flows are combined with trends in invisible and foreign borrowing to complete an international payments picture which includes trends in international debt and foreign exchange reserves.

In addition to the fundamental accounting equation linking output, domestic consumption and net trade, other accounting relationships equate valued added by origin with total final use, and total demand for investment with the supply of investment goods from sectors or origin. Many other accounting relationships are as introduced explicitly or implicitly above. In short, the model's sectors, variables and accounting relationships maximize the model's significance for a range of policy issues while at the same time leaving the model easy to manipulate and easy to link to a priori understandings of major economic relationships.

9.1.2 Production and Technology in the Model

The model's principle productivity component is the relationship between capital accumulation and output growth. Based on data from the 1950s through 1985, the relationship between increased investment and increased output was found to converge to a reasonably stable coefficient for capital productivity by which a stock of capital produces between one-fourth and one-fifth of its own value per year. The productivity changes with time and increased very rapidly in the early 1980s as rates of output growth far exceeded rates of increase in the national capital stock.

This capital productivity core of the formal model is summarized in the output-capital ratio (or its inverse, the capital-output ratio). An output-capital ratio measures how much output value, on average, a unit of capital (in value terms) produces. In simple pedagogical models, it is assumed to be constant to illustrate the role of national savings in determining output growth. But in its more sophisticated and practical modeling use it varies over time, and the variations can often be as important for determining growth rates as the additions to capital stock. The Rock Creek Research model uses both additions to capital stock and changes in the output-capital ratio to review China's past growth experience and estimate its future economic performance.

An economy's output-capital ratio is difficult to measure directly because it is difficult to value an economy's total capital stock. For one sector of an economy, say, metals, it would be possible to add up all the investments in mines and plants and dedicated transport systems, allow for depreciation and the value of repairs and improvements over the years, and estimate the value of all equipment, buildings, and other civil works directly related to the production of metals. For an economy as a whole, this method is difficult not only because depreciation and price changes make the actual valuation difficult, but also because certain categories of productive assets are difficult to value, in particular farm land. For a country such as China the method has the added drawback that data for many sectors are not available.

For China, Rock Creek Research has used an indirect method, however, to measure the average output-capital ratio, using a difference equation and different assumptions about initial output-capital ratios in the 1950s. The strict definitional relationships between capital stock, national savings, increases in capital stock, the output-capital ratio, and output requires that for any assumed output-capital ratio there be a change in its value from one year to the next to maintain the definitional relationships. If an initial value is too high, results in the next year will require a downward adjustment. If the value is too low, the adjustment is upward. Trial and error reveals that for virtually **any** assumed value in the early 1950s (including even the very fringes of the credible range), by the early 1980s the process of adjustment results in roughly the same output-capital ratio.

From this analysis, it is possible to estimate future output growth by hypothesizing a combination of increases in the capital stock and changes in the productivity (output-capital ratio) for that capital stock. In this way the model maintains consistency between the savings (capital accumulation) rate, the growth in aggregate output, and the increase (decrease) in productivity, referred to as "disembodied technical change" because the increased output is not linked to increases in equipment. Tables 9A-4 and 9A-12 (see the Appendix to this chapter) give the "Sources of Growth" for the model's low and high projections, dividing the total growth rate between "investment" (increase in capital stock) and "Other Sources" (changes in the output-capital ratio). In each table the growth from "other sources" is greatly reduced in the latter 1980s and actually becomes negative in the 1990s. At the same time, the savings rate declines, adding a further damping effect to the growth projections. From this perspective, the growth projections represent a lower bound on China's potential as shown by the experience of recent years.

There are many interpretations for such "disembodied technical change" in a simple capital-driven model, including increased labor-intensity, accumulation of skills, better quality capital goods not reflected in their price, higher rates of capacity utilization, weather variations, improved energy efficiency, degrees of political stability, improved management, and a different economic environment encouraging greater allocative efficiency. All of these factors are important in China today, and many of them are stimulated by technology transfer from foreign countries. As a result, it is variations in this degree of disembodied technical change which form one indication of the degree of technical transfer.

It is important to emphasize that much of this "disembodied technical change" is not technical change in the popular meaning of the phrase. The popular meaning of technical change implies elements such as new equipment, or new procedures on the shop floor, or new seed varieties in agriculture. In comparison to these "hard" components, elements such as increased capacity utilization, greater availability of inputs, improved weather, and political stability seem "soft." Other elements are technical in the economic sense but not in the popular sense, such as increased labor intensity. In China's case, many of the soft and purely economic meanings for technical change depend on the success of domestic policies and in particular the reforms under way in the economic system. Many of the popular or "hard" elements in technical change depend on transfers from Japan and the West.

For purposes of modeling, it is difficult to separate these into separate components or coefficients. It is possible after a few years to assume that there are no major weather changes or political upheavals, but it is difficult to gauge the impact of domestic reform, the degree of transfer of techniques from overseas, and the balance between the two. One guide is the path in the past half-dozen years, for which measures show very large gains from disembodied productivity change, most of which are probably due to productivity gains related to domestic reforms. The Rock Creek Research modeling has assumed that combined productivity gains from both sources will decline significantly in the second half of the 1980s, but in differentiating between high and low growth scenarios, increased productivity from technology transfer plays the most important roles, especially for the output of processed foods, consumer manufactures, and producer's machinery.

In the formal causality of the model, output growth is determined by planted area and yields in agriculture, and discretionary growth rates for gross value output in other sectors. For different savings (capital accumulation) rates, output growth is adjusted until the apparent level of disembodied technical change for the economy as a whole fits the technology transfer scenario under investigation.

As mentioned in Chapter 2, this specification of output technology follows that of the World Bank, in principal, with the differences that the World Bank capital productivity coefficients are specified for each economic sector, but do not vary from year to year according to assumptions about the pace of technology transfer. In the World Bank scenarios, the rates of disembodied technical change are adjusted to make the economy meet the official target of quadrupling gross value of agricultural and industrial output by 2000. Furthermore, the World Bank projections did not have data for the very high 1984-85 growth in time for inclusion in their calculations. In general, however, the Rock Creek Research model's inclusion of technology for output growth follows the most practical and theoretically most fundamental relationships, allowing maximum use of discretionary judgement drawing on the combination of trends in China's past and experience from other countries.

9.1.3 Domestic Consumption in the Model

There are three principal components of the model's consumption specification, all of them very standard: investment, final consumption (private and public combined), and intermediate use of produced goods by other productive enterprises.

Investment demand is satisfied by output and net imports in three sectors: machinery, other heavy industry (eg steel), and other productive sectors (eg construction). The growth trends in final use of these sectors are adjusted to accord with assumptions about the degree of machinery use in investment, and the total final use of these goods is constrained to match the economy's commitment to investment as reflected in the national accumulation rate for capital as a share of national product.

Final consumption by households and government is assumed to grow at rates which produce reasonable growth in per capita consumption for the relevant sectors (for example, slow and eventually declining for direct grain consumption, rising for processed foods, and rising even faster for consumer manufactures). There is no formal consideration of income elasticities, but in principle they are the implicit basis for judgments about final use.

Intermediate use of produced goods by other enterprises is formally determined for each sector in the model as the result of output, final use and trade patterns. The resulting intermediate-use patterns are monitored through the use of elasticities of total intermediate use with respect to Gross Domestic Product growth. In this way, trends in either conservation in inputs (as for energy) or increased use (as for farm raw materials and other productive sectors) can be compared with historical trends and with a priori estimates of progress China can make in increased efficiency and shifting of output structure. For the general researcher on China's economy, these elasticities have more significance that shifts in individual input-output coefficients, which are very large in number and which often require specialized technical knowledge about the sector which is most often unavailable.

The domestic consumption aspects of the model, then, are straightforward and allow easy interpretation of assumptions and modeling results alike.

9.1.4 International Trade in the Model

Specification of the foreign trade sectors is perhaps the most straightforward of all. Because the foreign exchange constraint is so critical and monitored so closely by policy makers, discretionary projections of current dollar exports and imports are made to fit some estimated permissible level of current account deficit and accumulated foreign debt. Using shadow exchange rates, the current dollar trade flows are converted to their constant-priced domestic currency equivalent and fit into the basic balancing equation by which output equals domestic use plus net exports. The discretionary dollar trade trends are then adjusted until domestic consumption requirements and acceptable sectoral output levels are reconciled.

Certain of the trade flows are affected by intermediate-use requirements, such as for energy and for other heavy industry, which for purposes of trade include large components of refined petroleum products, metals, and basic chemicals. But necessary imports are also constrained by foreign exchange earnings and borrowings. As a result, shifting more rapidly out of grain cultivation and depending on increased grain imports in the 1990s requires earning the foreign exchange needed to do so. Price relationships are also important in this respect -- especially for petroleum, and assumptions made about the future price of oil has some significance for foreign exchange earnings even if the volume of exports remains unchanged.

The foreign exchange constraint is shown in Tables 9A-8 and 9A-16, which present projections of China's balance of payments. Necessary foreign exchange reserves are determined in relation to the level of imports, as are invisibles, given the linkage between shipping and insurance receipts with trade in Chinese bottoms. With China's apparent willingness to borrow, as reflected in the negative levels of lending in these same tables, imports can be greater than exports, but only within reasonable limits.

In sum, imports and exports are tied to the model's overall balancing equation, but in general, exports determine the foreign exchange earnings and the capacity to borrow, and imports are governed by foreign exchange availability. This places considerable importance on the availability of foreign markets and the competitiveness of China's exports, in terms of both price and quality. These factors, in turn, are virtually impossible to model in an exercise of this scale, and once again the educated judgement of the modeler remains crucial. How much can technology transfer contribute to export competitiveness? Examination of individual case studies, such as those in this report, can help answer that question, because they add to the store of specialized knowledge brought to bear on the discretionary decision-making needs.

9.1.5 Reconciliation of the Separate Modeling Dimensions

As discussed in some length in Chapter 2, above, a modeling exercise such as the one outlined here may have formal specifications which make some trends discretionary and others determined by the model, but in fact all trends are to an important degree discretionary, because if some "result" generated by the model does not fit in a pre-determined reasonable range for the sector or variable, discretionary trends are adjusted until the result is acceptable by whatever independent criteria are used. the formal "result" is in this way adjusted in a discretionary way by playing with other trends in the model, which must of course stay within their own "reasonable" ranges.

The process by which this adjustment mechanism is manipulated can be extremely important for the final results of the modeling exercise because of the complexity of the modeling process and the difficulty of anticipating just what affect an adjustment in one sector of the model will have on another. if the process is overly cumbersome and unpredictable, the resulting high level of frustration from failure to satisfy all a priori ranges for all variables often results in ignoring those variables which are considered least important for the immediate analysis. In other words, a poorly designed model which is difficult to close acceptably, leads to poor projections with lower levels of internal consistency.

The Rock Creek Research model has been designed both to make the discretionary judgments meaningful and to allow secondary discretionary judgments to spread the adjustment process in predetermined and desired patterns over a range of endogenous or semi-endogenous parameters. This means that instead of the effect of an adjustment in one part of the model being reflected in only a single residual variable somewhere else, the influence is spread over several variables according to a rule which itself reflects a priori information. An example is the adjustment in final consumption which would be required if total value-added were increased due to a productivity change or increase in investment levels. Rather than have only one sector for one component in final domestic use absorb the shift, all absorb it according to weights reflecting consumer behavior and government choice.

Similarly, some variables are "semi-discretionary" because even though they are in principle set by the modeler, the collective influence of the variables results in partial adjustments in each to fit accounting and technical requirements in the model. Similar mechanisms exist in the World Bank model on a more complex scale, reflecting the greater complexity of its reconciliation needs.

This concludes the brief description of the Rock Creek Research model. It contains many standard technical and accounting relationships, but its specification has been enhanced to make its manipulations meaningful in a world increasingly rich with subsidiary data on the Chinese economy. At the same time, it has built in mechanisms for reducing the level of difficulty in reaching overall results which match a priori information for every variable in the system. It is this a priori information which is then essential to the results of the modeling scenarios, to which the next section turns.

9.2 A Low Technology Transfer Scenario for China's Economy

As can be seen from the comparisons in Chapter 2 and the detailed statistical results in the appendix to this chapter, even the low Rock Creek Research projection has growth well above the World Bank and official target projections, with growth over the entire period from 1981-2000 averaging 6.6 percent in real terms, compared to 5.5 percent for the World Bank quadrupling scenario and 5.6 percent for Lawrence Lau's high trade scenario.

This difference is not due to differences in assumptions about technology transfer, which are essentially ignored in the World Bank and Lau models. Rather, the higher Rock Creek Research estimate in the year 2000 results directly from incorporating China's output and productivity growth experience in the 1980s into the exercise. The World Bank projections used 1983 as their most recent historical year while Lau's report mentions that 1982 was the last year for which data were available to the model. The very rapid growth in 1984-85, following such strong economic records in 1982-83, conveys significant information about the potential for increases in productivity under the reforms, which in early 1986 continue to mature.

In a formal modeling sense, it was difficult to limit the model to even this level of growth, because of the assumptions that had to be made about a relatively sudden end to the increases in disembodied technical change through 1985. From 1983-85, disembodied technical change, that is, output gains not associated with capital accumulation, added 3 percent, 5 percent, and 7 percent to China's overall growth record, respectively. As mentioned above in the description of the model, this extra increase in output comes from a variety of sources, and there is no major reason to think that they should all cease to be significant in the late 1980s. Nevertheless, the Rock Creek Research low scenario gradually reduces the rate of capital accumulation and drastically reduces this level of non-capital productivity growth to still arrive at a "low" growth scenario showing that the gross value of agriculture and industry is quadrupled by 1995, not 2000. It is calculations such as these that prompt the most serious questioning of the official targets and hence of the general level of output in the World Bank projections.

Tables 9A-1, 9A-2, and 9A-3 in the appendix to this chapter give the essential growth results for the low scenario. In particular, the GDP growth trends in Table 9A-1 show the actual record in 1985, especially the poor agricultural record and the very strong industrial success (industrial growth here includes brigade industry). 1986 agriculture reflects some recovery from the poor weather, while the relatively low 1986 industrial growth rate reflects slow-down trends already apparent by the fourth quarter of 1985. Trends in the latter 1980s illustrate a trend growth slowdown which then continues through the 1990s.

The relationship of this scenario's results with those of official projections and the World Bank's modeling can be seen in Table 9A-2, from which it is clear that even in this low scenario the gross value output of agriculture and industry has increased five-fold rather than four-fold between 1980 and 2000.

The impact of low technology transfer on output is seen in the significant slow-down in industrial output growth by the late 1990s shown in Table 9A-1, column 2. From industrial growth averaging roughly 10 percent a year in the late 1980s, China's productivity is assumed to slow sufficiently so that by the end of the century it averages less than 4 percent over a five-year period. The continued strong growth in agriculture shown in the same table (Table 9A-1) is the result of switching crop land out of low value-yielding grains into vegetables and fruits with an enormously greater yuan ouput per hectare. This source of substantial output growth is not found in models for which agricultural output is essentially a product of capital and labor inputs alone, as is the case with both the World Bank and Lau models. Nor is this trend dependent on technology transfer from abroad.

The trade projections in the low scenario reflect the assumption that China will have a relatively low level of product quality in consumer manufactures and will not have any capacity to export motor vehicles by the end of the century. As a result, total real exports as a share of GDP

(Gross Domestic Product) remain relatively stable, shifting from 12.3 percent in 1981 to 9.5 percent in 1990 and 11.8 percent in the year 2000. By comparison, exports in the World Bank "quadrupling" scenario (see Chapter 2 for an explanation) grow to 8.9 percent of GDP in 1990 and 11.0 percent in 2000. Comparable comparisons for the Lau modeling are not directly available because of the units used and the lack of an exchange rate relating them. However, in Lau's units (1970 yuan for GDP and 1972 dollars for real trade), exports as a share of GDP roughly halve between 1981 and 2000, so in 2000 exports are roughly 6 percent of GDP, much lower than in either the Rock Creek Research or World Bank projections. For the growth rates associated with these real export levels, see Table 9A-7.

Although the Rock Creek Research and World Bank estimates of exports as a percentage of GDP are rather close, the more rapid growth of GDP overall in the Rock Creek Research scenario implies a higher level of overall exports in the Rock Creek trade projections. Finally, shifting to an analysis of trade in current dollars, the World Bank's world inflation estimates were based on trends in the early 1980s, while the Rock Creek Research inflation expectations reflect the much lower prospects for world inflation overall after the drop in oil prices in the first half of 1986. As a result, the World bank current dollar exports are shown to have grown by more than ten-fold by the year 2000, while those from the Rock Creek Research "Low" scenario increase only four-fold. Lau's current dollar exports less than double over the same period. For these current-priced dollar export results see Tables 9A-5, 9A-6, and 9A-8.

9.3 A High Technology Transfer Scenario for China

With the "Low" Rock Creek Research scenario already higher then either the World Bank or Lawrence Lau "High" scenarios, the Rock Creek Research "High" technology transfer projection represents by far the most optimistic picture of China's economy in the year 2000. The projection is based on the assumption that China acquires and absorbs a range of technologies which markedly raise productivity and output quality throughout the economy, especially in the machinery and consumer manufacturing sectors.

Compared to the 6.6 percent growth of real output from 1981 to 2000 in the Rock Creek Research Low scenario (and compared to 5.5 percent for the World Bank), the Rock Creek Research "High" scenario results in 8 percent real growth over the same 1981-2000 period. This is not as high as the real growth rate for Japan's economy during the decade of the 1960s, it nevertheless is a very high rate of expansion to sustain over such a long period of time. Nevertheless, given China's late start in the acquisition of modern technology and the many non-technical factors favoring its rapid absorption, 8 percent real growth represents a realistic picture of what could happen if China succeeds in fully implementing her technology transfer goals.

In the Rock Creek Research modeling for the "High" scenario, as for the Low scenario, the level of capital accumulation and the increase in disembodied technical change (i.e. independent increases in productivity due to learning, higher capacity utilization, more efficient resource allocation, and in general all the many ways in which output can be increased without increasing the capital stock) determine the rate of growth. For the High scenario, this higher rate of disembodied capital productivity growth adds roughly 1 percentage point to the GDP growth rate in the late 1990s and less than 0.5 percent to GDP growth in the 1990s, relative to the Low scenario. At the same time, even though the savings rate (rate of capital accumulation) is lower in the High scenario than in the Low one, growth due to simple capital accumulation in the 1990s is slightly higher than in the Low scenario, because of the higher level of average capital productivity by then.

In other words, the increases needed in growth due to disembodied change in overall productivity need not be dramatic to result in the Rock Creek Research High scenario. Just as for the Low scenario, the productivity assumptions still imply a drastic slow-down from the rapid increases in such productivity through 1985 and even imply an actual decline in such productivity after 1989. The Rock Creek Research High projection is much higher than that of the World Bank and higher still than Lau's high projection. Nevertheless, it is a realistic and entirely plausible path for China's economy given strong success in technology transfer.

Growth results for the Rock Creek Research High Scenario are given in Tables 9A-9, 9A-10, and 9A-11. Differences with the Low Scenario (see above) only become apparent after 1987 and are not highly significant until the 1990s. Similarly, agricultural output and output of "other" sectors (services) shows very little difference from the Low scenario. Industrial output, however, finishes the century much stronger than in the Low scenario. This can be seen in column 2 of Table 9A-9. Rather than averaging only 3.9 percent for the last half of the 1990s, the High Scenario industrial growth rate averages 6.7 percent. In general, from roughly a one-percent growth rate over the Low Scenario in the late 1980s, the impact of successful technology transfer compared to poor transfer is more than two percentage points by the year 2000.

As shown in Table 9A-10, the Chinese official benchmark, gross value output of agriculture and industry, grows by more than six-fold between 1980 and 2000, rather than the official and World Bank target of four-fold and the Low Scenario result of 5-fold. This relatively high growth trend is possible in spite of a slight decline in "disembodied productivity change" in the 1990s, and very moderate increases in the late 1980s, far below the trend for 1983-85. These "sources of growth" results can be seen in Table 9A-12 in the appendix to this chapter, especially the last three columns.

Turning to the trade projections for the Rock Creek Research High scenario, the assumption is made that with successful technology transfer, China will come to dominate the apparel export market to OECD economies, replace South Korea for most basic and some sophisticated consumer electronics products, and just be beginning to export automobiles to third-world economies, if not to the OECD world. Real exports in the High Scenario grow an average of 10.5 percent a year in real terms, and exports as a share of GDP grow from 12.3 percent in 1981 to 10.2 percent in 1990, to 17 percent in the year 2000. This is above Japan's share for the early 1980s (roughly 14 percent) but below Indonesia's (roughly 23 percent) and essentially the same as the average rate for industrialized market economies. The implication is that China's acquisition of technology for high-quality exports, coupled with very low labor costs, will make China a very competitive and successful source for manufactured exports throughout the world.

Statistics on China's trade in the High Scenario are given in Tables 9A-13, 9A-14, 9A-15, and 9A-16. In particular, the growth of exports for processed foods, consumer manufactures, and machinery is much higher than in the Low Scenario (Tables 9A-9 through 9A-12). This is the result of technology transfer, which most directly influences these industrial sectors. The balance-of-payments results are presented in Table 9A-16, and in general, although trade turn-over in the year 2000 is nearly 40 billion dollars greater than in the Low Scenario, the trade deficit is lower, as is the overall level of net borrowing in the 1990s. This is because the model's results for domestic consumption reflect more than satisfactory increases in most categories.

This concludes the review of the Rock Creek Research model and its High and Low projections. Statistical details of the two projections are given without further analysis in the chapter's Annex, below.

ANNEX TO CHAPTER 9
SAMPLE STATISTICAL RESULTS OF THE HIGH AND LOW SCENARIOS

For analysis and discussion of these and other results, see Chapters 2 and 9, above.

Table 9A-1
LOW SCENARIO
1980 DOLLAR GDP GROWTH (Annual Average Percent)

	Agri-culture	Indus-try	Other	Total	Per Capita
1981	8.1	2.5	7.6	6.5	5.1
1982	13.1	6.8	-2.0	7.3	5.7
1983	9.5	11.7	4.5	8.7	7.7
1984	12.9	15.8	16.3	14.4	13.4
1985	1.0	21.1	21.7	11.3	10.1
1986	8.4	8.5	12.9	9.7	8.5
1987	6.8	12.9	17.1	11.4	10.2
1988	5.3	11.6	14.4	9.8	8.6
1989	4.8	9.1	12.0	8.2	7.1
1990	4.4	8.2	10.5	7.5	6.3
1995	4.3	6.1	8.3	6.2	5.1
2000	5.6	3.9	6.6	5.5	4.4
2005	7.8	4.2	5.7	6.1	4.9

Table 9A-2
LOW SCENARIO
GROSS VALUE OUTPUT (Billion 1980 Yuan)

	Agri-culture	Indus-try	Agricul-ture & Industry	Other Output	Total Gross Output
1980	198	522	720	134	854
1981	209	546	755	138	892
1982	233	588	821	156	977
1983	251	654	905	173	1,078
1984	280	761	1,041	186	1,226
1985	288	923	1,211	214	1,425
1986	311	1,009	1,320	233	1,553
1987	333	1,150	1,483	266	1,749
1988	350	1,298	1,649	300	1,949
1989	367	1,433	1,800	335	2,136
1990	384	1,571	1,955	369	2,324
1995	487	2,280	2,766	517	3,283
2000	654	2,971	3,625	660	4,285
2005	972	3,918	4,891	765	5,655

Table 9A-3
LOW SCENARIO
GROSS VALUE OUTPUT GROWTH (Percent Annual Average)

	Agri- culture	Indus- try	Agricul- ture & Industry	Other Output	Total Gross Output
1981	5.9	4.5	4.9	2.6	4.5
1982	11.3	7.8	8.8	13.5	9.5
1983	7.7	11.2	10.2	10.9	10.3
1984	11.7	16.3	15.0	7.2	13.8
1985	2.8	21.4	16.4	15.2	16.2
1986	8.0	9.3	9.0	9.0	9.0
1987	6.9	14.0	12.4	14.0	12.6
1988	5.4	12.8	11.2	13.0	11.5
1989	4.8	10.4	9.2	11.5	9.6
1990	4.6	9.6	8.6	10.0	8.8
1995	4.8	7.7	7.2	7.0	7.2
2000	6.1	5.4	5.6	5.0	5.5
2005	8.3	5.7	6.2	3.0	5.7

Table 9A-4
LOW SCENARIO
SOURCES OF GROWTH

	% NMP Savings	% GDP Savings	Capital Produc- tivity	Produc- tivity Growth	Real NMP Growth	Growth from Invest- ment	Growth from Other Sources
1981	28.5	22.1	.222	-2.2	4.9	7.2	-2.3
1982	29.0	22.8	.227	2.3	8.1	6.3	1.8
1983	29.7	23.5	.232	2.2	9.8	6.6	3.2
1984	31.2	24.5	.243	4.7	13.9	6.9	7.0
1985	34.5	26.7	.255	4.8	12.7	7.6	5.2
1986	34.0	26.0	.254	-.3	8.5	8.8	-.3
1987	33.1	25.1	.259	2.0	10.9	8.6	2.2
1988	32.7	24.5	.261	.9	9.5	8.6	.9
1989	31.8	23.7	.260	-.6	7.9	8.5	-.7
1990	30.5	22.6	.257	-1.2	7.0	8.3	-1.3
1995	30.0	21.1	.224	-2.7	5.1	8.0	-2.9
2000	32.0	21.4	.194	-2.9	3.9	7.0	-3.1
2005	32.0	20.5	.176	-1.9	4.5	6.5	-2.0

UNITS: Capital productivity in Yuan of output per Yuan of capital stock. All growth in percent annual average growth.

Table 9A-5
LOW SCENARIO
DOLLAR EXPORTS (Billion Current US Dollars)

	Grain	Other Foods	Farm Raw Mater'ls	Pro- cessed Foods	Consumer Manu- factures	Energy and Fuels	Machi- nery	Farm Chemi- cals	Other Heavy Industry	Exports Total
1980	.6	2.3	1.8	.2	6.9	4.5	1.0	.0	.9	18.1
1981	.4	2.5	1.9	.4	8.2	5.1	1.1	.0	2.4	22.0
1982	.4	2.6	1.7	.4	8.3	5.5	1.3	.0	2.1	22.3
1983	.6	2.5	2.0	.4	8.7	4.8	1.3	.0	1.8	22.2
1984	1.5	1.7	2.4	.4	9.7	6.0	1.5	.0	1.8	24.9
1985	2.3	1.8	2.6	.5	8.7	7.4	1.5	.0	1.8	26.5
1986	.8	1.4	2.9	.5	10.4	3.8	1.6	.0	1.8	23.3
1987	1.0	1.6	3.3	.6	11.5	3.8	1.7	.0	1.9	25.4
1988	1.1	1.7	3.7	.7	12.6	4.1	1.8	.0	2.0	27.6
1989	1.1	1.8	4.1	.8	13.9	4.3	1.9	.0	2.1	30.1
1990	1.2	2.0	4.6	.9	15.5	4.6	2.1	.0	2.4	33.2
1995	1.3	2.1	5.8	1.3	22.2	6.1	2.6	.0	2.9	44.2
2000	1.4	2.2	7.4	1.8	31.1	9.9	3.2	.0	3.5	60.4
2005	1.5	2.4	9.5	2.5	43.6	12.8	3.8	.0	4.3	80.4

Table 9A-6
LOW SCENARIO
DOLLAR IMPORTS (Billion Current US Dollars)

	Grain	Other Foods	Farm Raw Mater'ls	Pro- cessed Foods	Consumer Manu- factures	Energy and Fuels	Machi- nery	Farm Chemi- cals	Other Heavy Industry	Exports Total
1980	3.2	.4	2.7	.1	.4	.2	5.0	.4	5.4	17.8
1981	3.6	.4	3.0	.3	.5	.0	5.3	.4	6.4	19.4
1982	3.7	.5	2.3	.2	.4	.2	2.9	.5	6.8	16.9
1983	2.4	.5	2.3	.2	.7	.1	3.7	.7	9.4	18.7
1984	1.7	.3	2.2	.2	1.0	.1	6.3	.8	11.1	23.9
1985	1.6	.3	2.9	.3	1.7	.2	11.1	1.0	14.8	36.2
1986	1.7	.3	2.3	.2	1.1	.2	7.4	.7	12.0	25.9
1987	1.7	.3	2.6	.2	1.5	.3	8.9	.7	12.9	29.1
1988	2.0	.3	2.9	.2	2.2	.4	12.0	1.0	14.8	35.8
1989	2.2	.4	3.2	.3	2.4	.9	13.2	1.0	15.7	39.2
1990	2.4	.4	3.5	.3	2.7	2.1	14.5	1.1	16.6	43.7
1995	3.3	.6	4.5	.4	3.4	7.3	18.7	1.4	19.9	59.5
2000	4.5	.7	5.7	.5	4.4	17.0	24.0	1.7	24.3	82.8
2005	6.0	1.0	7.3	.6	5.6	31.5	30.7	2.0	29.5	114.2

Table 9A-7
LOW SCENARIO
REAL GROWTH OF EXPORTS (Annual Average Growth)

	Grain	Other Foods	Farm Raw Mater'ls	Pro-cessed Foods	Consumer Manu-factures	Energy and Fuels	Machi-nery	Farm Chemi-cals	Other Heavy Industry	Exports Total
1981	-22.1	62.1	16.3	146.3	25.9	-4.8	18.0	-	223.1	33.1
1982	-.8	72.7	-.2	28.8	12.2	9.8	38.8	-	-17.4	15.0
1983	57.0	-7.1	2.3	-3.5	3.2	-3.4	-3.8	-	4.1	1.6
1984	156.8	-4.1	24.6	4.7	11.8	30.7	17.3	-	-13.3	10.7
1985	57.7	23.1	12.2	14.1	-14.6	46.5	-4.3	-	2.3	-5.9
1986	-64.3	-25.7	16.8	11.2	21.9	2.1	10.6	-	6.5	12.5
1987	19.4	13.3	9.4	9.5	7.4	10.3	6.2	-	4.7	8.0
1988	3.0	2.2	7.9	9.1	6.5	11.7	8.7	-	7.6	6.7
1989	2.2	1.2	7.5	9.8	8.6	7.2	11.6	-	8.9	8.1
1990	3.4	3.4	8.6	11.9	10.2	4.0	13.3	-	9.8	9.6
1995	-1.8	-1.8	2.7	4.2	9.7	2.7	6.4	-	3.3	7.8
2000	-1.6	-1.6	2.9	3.9	9.1	6.8	6.1	-	2.6	8.0
2005	-1.3	-1.3	3.2	4.2	9.2	2.2	5.9	-	2.2	8.1

Table 9A-8
LOW SCENARIO
BALANCE OF PAYMENTS AND DEBT (BILLION CURRENT DOLLARS)

	Exports	Imports	Trade Bal-ance	Invi-sibles Net	Current Account Balance	Lending Net	Increase In Reserves
1980	18.1	17.8	.3	.3	.6	-1.8	.1
1981	22.0	19.4	2.6	.4	3.0	.7	2.5
1982	22.3	16.9	5.4	1.4	6.8	-.3	6.3
1983	22.2	18.7	3.5	2.3	5.8	.2	3.6
1984	24.9	23.9	1.0	2.0	3.0	1.0	.0
1985	26.5	36.2	-9.7	3.5	-6.2	-2.1	-4.1
1986	23.3	25.9	-2.6	2.7	.0	2.8	-2.7
1987	25.4	29.1	-3.7	3.0	-.7	1.0	-1.7
1988	27.6	35.8	-8.2	3.5	-4.8	-6.2	1.4
1989	30.1	39.2	-9.1	3.8	-5.2	-5.6	.4
1990	33.2	43.7	-10.5	4.2	-6.3	-6.9	.6
1995	44.2	59.5	-15.3	5.7	-9.6	-13.6	4.1
2000	60.4	82.8	-22.4	7.9	-14.5	-20.5	6.0
2005	80.4	114.2	-33.8	10.7	-23.1	-31.2	8.1

Table 9A-9
HIGH SCENARIO
1980 DOLLAR GDP GROWTH (Annual Average Percent)

	Agri-culture	Indus-try	Other	Total	Per Capita
1981	8.1	2.5	7.6	6.5	5.1
1982	13.1	6.8	-2.0	7.3	5.7
1983	9.5	11.7	4.5	8.7	7.7
1984	12.9	15.8	16.3	14.4	13.4
1985	1.0	21.1	21.7	11.3	10.1
1986	8.4	8.5	12.9	9.7	8.5
1987	6.2	12.9	17.1	11.2	9.9
1988	5.3	12.9	14.5	10.2	8.9
1989	4.8	10.7	12.3	8.8	7.6
1990	4.6	9.3	10.9	8.0	6.8
1995	4.5	8.4	8.6	7.0	5.9
2000	5.7	6.7	7.0	6.5	5.3
2005	7.8	5.8	5.7	6.4	5.3

Table 9A-10
HIGH SCENARIO
GROSS VALUE OUTPUT (Billion 1980 Yuan)

	Agri-culture	Indus-try	Agricul-ture & Industry	Other Output	Total Gross Output
1980	198	522	720	134	854
1981	209	546	755	138	892
1982	233	588	821	156	977
1983	251	654	905	173	1,078
1984	280	761	1,041	186	1,226
1985	288	923	1,211	214	1,425
1986	311	1,009	1,320	233	1,553
1987	331	1,150	1,481	266	1,747
1988	349	1,315	1,664	301	1,965
1989	365	1,484	1,849	338	2,187
1990	383	1,671	2,053	375	2,428
1995	488	2,703	3,191	543	3,734
2000	657	4,031	4,688	733	5,421
2005	976	5,739	6,716	880	7,596

Table 9A-11
HIGH SCENARIO
GROSS VALUE OUTPUT GROWTH (Percent Annual Average)

	Agriculture	Industry	Agriculture & Industry	Other Output	Total Gross Output
1981	5.9	4.5	4.9	2.6	4.5
1982	11.3	7.8	8.8	13.5	9.5
1983	7.7	11.2	10.2	10.9	10.3
1984	11.7	16.3	15.0	7.2	13.8
1985	2.8	21.4	16.4	15.2	16.2
1986	8.0	9.3	9.0	9.0	9.0
1987	6.3	14.0	12.2	14.0	12.5
1988	5.4	14.3	12.3	13.3	12.5
1989	4.8	12.8	11.1	12.1	11.3
1990	4.7	12.6	11.0	10.9	11.0
1995	5.0	10.1	9.2	7.7	9.0
2000	6.1	8.3	8.0	6.2	7.7
2005	8.2	7.3	7.5	3.7	7.0

Table 9A-12
HIGH SCENARIO
SOURCES OF GROWTH

	% NMP Savings	% GDP Savings	Capital Productivity	Productivity Growth	Real NMP Growth	Growth from Investment	Growth from Other Sources
1981	28.5	22.1	.222	-2.2	4.9	7.2	-2.3
1982	29.0	22.8	.227	2.3	8.1	6.3	1.8
1983	29.7	23.5	.232	2.2	9.8	6.6	3.2
1984	31.2	24.5	.243	4.7	13.9	6.9	7.0
1985	34.5	26.7	.255	4.8	12.7	7.6	5.2
1986	34.0	26.0	.254	-.3	8.5	8.8	-.3
1987	32.9	24.9	.259	1.9	10.7	8.6	2.0
1988	32.3	24.3	.263	1.6	10.2	8.5	1.7
1989	30.8	23.0	.264	.3	8.8	8.5	.3
1990	29.7	22.0	.263	-.3	7.8	8.1	-.3
1995	29.3	20.9	.247	-1.3	6.6	8.0	-1.4
2000	29.9	20.6	.228	-1.6	5.7	7.5	-1.7
2005	30.3	20.3	.210	-1.6	5.4	7.1	-1.7

UNITS: Capital productivity in Yuan of output per Yuan of capital stock. All growth in percent annual average growth.

Table 9A-13
HIGH SCENARIO
DOLLAR EXPORTS (Billion Current US Dollars)

	Grain	Other Foods	Farm Raw Mater'ls	Pro-cessed Foods	Consumer Manu-factures	Energy and Fuels	Machi-nery	Farm Chemi-cals	Other Heavy Industry	Exports Total
1980	.6	2.3	1.8	.2	6.9	4.5	1.0	.0	.9	18.1
1981	.4	2.5	1.9	.4	8.2	5.1	1.1	.0	2.4	22.0
1982	.4	2.6	1.7	.4	8.3	5.5	1.3	.0	2.1	22.3
1983	.6	2.5	2.0	.4	8.7	4.8	1.3	.0	1.8	22.2
1984	1.5	1.7	2.4	.4	9.7	6.0	1.5	.0	1.8	24.9
1985	2.3	1.8	2.6	.5	8.7	7.4	1.5	.0	1.8	26.5
1986	.8	1.4	2.9	.5	10.4	3.8	1.6	.0	1.8	23.3
1987	1.0	1.6	3.3	.6	11.5	3.8	1.7	.0	1.9	25.4
1988	1.1	1.7	3.7	.7	12.8	4.1	1.8	.0	2.0	27.9
1989	1.1	1.8	4.1	.8	14.8	4.3	2.0	.0	2.1	31.1
1990	1.2	2.0	4.6	.9	17.4	4.6	2.2	.0	2.4	35.3
1995	1.2	2.1	5.7	1.6	31.1	6.1	3.1	.0	2.9	53.7
2000	1.3	2.3	7.3	2.6	54.4	9.6	5.4	.0	3.5	86.3
2005	1.4	2.5	9.4	4.1	93.9	12.3	9.8	.0	4.3	137.7

Table 9A-14
HIGH SCENARIO
DOLLAR IMPORTS (Billion Current US Dollars)

	Grain	Other Foods	Farm Raw Mater'ls	Pro-cessed Foods	Consumer Manu-factures	Energy and Fuels	Machi-nery	Farm Chemi-cals	Other Heavy Industry	Imports Total
1980	3.2	.4	2.7	.1	.4	.2	5.0	.4	5.4	17.8
1981	3.6	.4	3.0	.3	.5	.0	5.3	.4	6.4	19.4
1982	3.7	.5	2.3	.2	.4	.2	2.9	.5	6.8	16.9
1983	2.4	.5	2.3	.2	.7	.1	3.7	.7	9.4	18.7
1984	1.7	.3	2.2	.2	1.0	.1	6.3	.8	11.1	23.9
1985	1.6	.3	2.9	.3	1.7	.2	11.1	1.0	14.8	36.2
1986	1.7	.3	2.3	.2	1.1	.2	7.4	.7	12.0	25.9
1987	1.7	.3	2.6	.2	1.5	.3	10.0	.7	12.9	30.2
1988	2.0	.3	2.9	.2	2.2	.4	13.9	1.0	14.9	37.9
1989	2.2	.4	3.2	.3	2.5	.8	16.4	1.0	16.1	42.8
1990	2.5	.4	3.5	.3	2.8	1.9	18.8	1.1	17.3	48.5
1995	3.4	.6	4.5	.4	3.9	5.6	30.0	1.4	21.3	70.9
2000	4.6	.8	5.7	.5	5.3	12.1	44.5	1.7	27.4	102.5
2005	6.2	1.1	7.3	.7	7.1	21.1	65.9	2.0	35.8	147.2

Table 9A-15
HIGH SCENARIO
REAL GROWTH OF EXPORTS (Annual Average Growth)

	Grain	Other Foods	Farm Raw Mater'ls	Processed Foods	Consumer Manufactures	Energy and Fuels	Machinery	Farm Chemicals	Other Heavy Industry	Exports Total
1981	-22.1	62.1	16.3	146.3	25.9	-4.8	18.0	-	223.1	33.1
1982	-.8	72.7	-.2	28.8	12.2	9.8	38.8	-	-17.4	15.0
1983	57.0	-7.1	2.3	-3.5	3.2	-3.4	-3.8	-	4.1	1.6
1984	156.8	-4.1	24.6	4.7	11.8	30.7	17.3	-	-13.3	10.7
1985	57.7	23.1	12.2	14.1	-14.6	46.5	-4.3	-	2.3	-5.9
1986	-64.3	-25.7	16.8	11.2	21.9	2.1	10.6	-	6.5	12.5
1987	19.4	13.3	9.4	9.5	7.4	10.3	6.2	-	4.7	8.0
1988	2.8	2.2	7.9	10.7	8.6	11.6	9.2	-	7.6	8.3
1989	1.9	1.3	7.5	11.3	13.3	7.0	13.0	-	8.9	11.5
1990	3.1	3.6	8.6	13.8	16.6	4.1	16.0	-	9.8	14.4
1995	-2.1	-1.6	2.6	7.7	14.5	2.5	9.1	-	3.3	12.0
2000	-1.9	-1.4	2.8	7.3	14.1	6.5	14.1	-	2.6	12.9
2005	-1.6	-1.0	3.3	6.5	13.8	2.0	15.1	-	2.2	13.1

Table 9A-16
HIGH SCENARIO
BALANCE OF PAYMENTS AND DEBT (BILLION CURRENT DOLLARS)

	Exports	Imports	Trade Balance	Invisibles Net	Current Account Balance	Lending Net	Increase In Reserves
1980	18.1	17.8	.3	.3	.6	-1.8	.1
1981	22.0	19.4	2.6	.4	3.0	.7	2.5
1982	22.3	16.9	5.4	1.4	6.8	-.3	6.3
1983	22.2	18.7	3.5	2.3	5.8	.2	3.6
1984	24.9	23.9	1.0	2.0	3.0	1.0	.0
1985	26.5	36.2	-9.7	3.5	-6.2	-2.1	-4.1
1986	23.3	25.9	-2.6	2.7	.0	2.8	-2.7
1987	25.4	30.2	-4.8	3.1	-1.7	-.4	-1.3
1988	27.9	37.9	-10.1	3.6	-6.5	-6.1	1.7
1989	31.1	42.8	-11.7	4.1	-7.6	-8.4	.7
1990	35.3	48.5	-13.2	4.6	-8.6	-9.5	.9
1995	53.7	70.9	-17.1	6.9	-10.3	-16.0	5.7
2000	86.3	102.5	-16.2	10.4	-5.8	-13.9	8.1
2005	137.7	147.2	-9.5	15.7	6.2	-5.3	11.5

CHINA'S EVOLVING COMPUTER INDUSTRY:
THE ROLE OF FOREIGN TECHNOLOGY TRANSFERS

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A. Introduction

> "In the 1950s we began to develop computers through copying; since then, there has always been a tendency to emphasize hardware over software, mainframes over peripherals and components, research and design over technology and production, applicative experiments over practical results. Thus, for a long time, computers produced in our country have been known to be unreliable, unsupported, not easy to use, and not easy to repair. Moreover, we have too many varieties of computers which are largely identical with only a few minor differences. In addition, our computers are not produced in batches and development is rather slow. As facts have proven, this is not a good strategy for developing computers."[1]
> (Remarks of a researcher from the Institute of Computer Technology, Chinese Academy of Sciences)

Since the announcement of the four modernization program in the mid-1970s, China has paid special attention to the development of its computer industry. In the March 1978 S&T plan, for example, computers were one of the eight priority areas singled out by the leadership. The main impetus for pushing ahead in the computer area derives from a blend of scientific, industrial, and defense-related imperatives. Chinese leaders hope to move China into the so-called "age of informatics" by encouraging the widespread utilization of computers in all sectors of the economy and society. This effort, which has undergone a number of twists and turns since 1978, has high level support among both the political as well as the scientific community. And, in some areas, it has already begun to yield appreciable results. In contrast to the previous focus on mainly scientific calculations, computers are being used today in bookkeeping, inventory control, production control, product design, medical diagnosis, and traffic management.

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[1] Wang Xinggang, "Ideas on Developing Computers in Our Country," Ziran Bianzhengfa Tongxun, Number 6, 1982, pp.3-5 translated in JPRS 83064, March 14, 1983, pp.1-5.

This report provides a series of assessments regarding China's strategy and objectives for computer development. It examines the specific role played by acquisition of foreign computers and related know-how by the PRC, stressing what the likely impact of recent and future computer imports in China will be. A list of selected imports and other forms of foreign participation is provided in the appendix. The information contained in the report is based on an extensive review of Chinese and English language sources on computer development; b)interviews with US computer firms engaged in China-related business; and c)a series of field trips to China, one in July 1985 to Shanghai and a second to Beijing in January 1986. In the case of the former, interviews and site visits concentrated on Shanghai's role as a local computer and electronics base in China's overall development. In the case of the latter, meetings were held with government officials in the State Council, Ministry of Electronics Industry, and various other "centrally-led" organizations to ascertain Beijing's goals and intentions regarding national computer development.

B. Overall Perspective

Chinese leaders will continue to attach great importance to the expanded development and more effective application of computers. The PRC push in the computer area bears a number of similarities with the French effort of the 1970s. Nora and Minc, in their seminal work entitled The Computerization of Society, highlight the features of a national plan in France designed to minimize dependence on foreign sources of technology and equipment while harnessing computers to stimulate economic and social change.[2] Similarly, the PRC's primary aim is to establish a strong indigenous-based computer capability. The leadership, from Premier Zhao Ziyang on down, sees increased computerization as a necessary prerequisite to attaining desired advances in scientific research, industrial productivity, national communications, and defense capabilities, especially regarding strategic weapons programs. This high level of support is manifested in increased investment and related funding for indigenous computer R&D programs, modernization of key manufacturing facilities, and training programs in all segments of the education system.

As of the end of 1985, China had approximately 300,000 computers in place.[3] Mainframes and minicomputers accounted for about 7,000 or so of this total.[4] Between 1983 and 1985, the number of microcomputers increased by almost 600%, growing from about 40,000 to over 250,000 during this short span of time. The dominant field of use was in computation in research and engineering, accounting for 60% of the user rate. In contrast, by early 1984 there were well over 2 million microcomputers in use in the US, with the dominant users (as measured by relative spending) being the banking, insurance, and business services industries.[5]

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[2] Simon Nora and Alain Minc, The Computerization of Society (Cambridge: MIT Press, 1980).

[3] This total includes single-board and 8-bit computers as well as mainframes, mini-, and microcomputers.

Since the implementation of the so-called "open door policy," the most remarkable feature of China's computerization experience has been the rapid growth of imported computers, especially microcomputers.[6] One estimate suggests that such imports grew from 4,500 in 1983 to 105,000 in 1984! Only about 5.0% of these imports, however, were acquired as final product units; the majority were brought into China via Hong Kong as assembly kits due to the structure of China's import duties at the time and Western controls/delays on the export of the technology embodied in many of these machines.[7] In large part, it is the immediate dissatisfaction with the growing dependence on imports combined with concerns about excessive expenditures of foreign exchange that have driven the push to build up indigenous R&D and manufacturing capacity.

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[4] This figure comes from Li Xianglin, director of the office of the Leading Group for Electronics under the State Council. See "Computers Brave All Walks of Nation's Life," China Daily, June 6, 1986.

[5] Tom Forester, ed., The Information Revolution (Cambridge: MIT Press, 1985).

[6] Interestingly, the use and import of computers appears to be geographically dispersed throughout the country--though it does appear that the key coastal areas have been able to respond to import opportunities more rapidly because of foreign exchange availability.

Current development efforts must also be seen against the backdrop of China's pre-1978 experience with computer R&D and production. The history of computer development has been characterized by uneven performance, with serious problems of machine compatibility and software generalizability. The Chinese produced their first electron-tube computer (103) in 1958; the first transistorized computers (109B, 441B, 121, and X-2) appeared in the mid-1960s. The onset of the Cultural Revolution, however, dealt a severe setback to computer development at a time when the West was just starting to catapult ahead. Nonetheless, by the early 1970s, the first series of computers with integrated circuit technology appeared (111, 112, 150, and 655). These achievements were attained by a small, selected group of specialists working, in many cases, without the benefit of a strong R&D support network.

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[7] According to officials at MOFERT, in January 1985, a new set of import duties went into effect. For machines above the 32-bit word length, duties range from 10-12%; the rate for spare parts for these machines runs 7.5-10%. For machines below the 32-bit level, duties ranges from 50-70%; the duty on spare parts for these machines is between 30-40%.

The milestone in China's computer development occurred in 1973 with the introduced of the first serialized machines, the DJS-100 series. Modelled after the NOVA computer developed in the US, the DJS-100 series expanded to include a number of different models capable of meeting the needs of a variety of users. In general, these machines were much slower than their Western counterparts and lacked much of the software to support widespread use. About the same time, the DJS-200 series also appeared, modelled after the IBM-360 series. While a number of machines were produced, they never really attained the levels of performance associated with the IBM. While some of these machines were hand tailored to meet the needs of special end-users, such as the PRC defense sector, they never entered large-scale serial production. In essence, the most serious Chinese deficiency is that they have been able to produce many one or two of a kind machines, most of which are of the stand-alone variety, but have never been able to move ahead into the stage of large-scale production due to specific technical shortcomings and a host of political problems. (See Chart 3)

The objective of developing a technologically advanced computer industry is to be supported, in large part, by the concerted effort being made to improve the quality of China's domestic semiconductor and electronic components industry,[8] including several large programs to perfect large-scale integrated circuits in both the memory and logic areas.[9] There are 17 major enterprises in China engaged in research and production of integrated circuits.[10] Low yields and poor reliability have been major problems plaguing China's IC industry. At present, almost all the manufacturers of key computers in China rely extensively on imported chips, etc.[11] Recognizing that backwardness in microelectronics has been a major obstacle to further computer development, enhancement of existing capabilities is now a high priority element of the country's overall computer development strategy.[12]

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[8] See "State Council Urges Priority for Electronics," Xinhua, January 11, 1985 translated in FBIS-PRC, January 11, 1985, p.K25. See also Wang Yangyuan, "On the Technical Targets China's

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Integrated Circuits Should Reach in the 1990s," Jisuanji Shijie, #9, May 8, 1984, p.3 translated in JPRS-CST-85-017, June 11, 1985, pp.90-92.

[9] Computers are also an important ingredient in the development of microelectronics in China. For example, an intelligent analysis and design system for integrated circuits was recently developed by the Institute of Automation and the Institute of Metallurgy under the CAS. With the help of a computer, the technology of artificial intelligence, pattern recognition, and IC design can be combined to analyze complex circuitry, and design and verify layouts. China Daily, March 19, 1986.

[10] "Microelectronics Industry Makes Big Connections," China Daily, April 7, 1986.

[11] Even among the memory chips and microprocessors that are domestically produced, the majority are modelled after existing foreign models. A new single-board microcomputer (TWS 0600) developed at the Tianjin Institute of Computer Technology, for example, uses the Motorola MC6800 (with some modifications) as its central processing unit.

[12] In late 1985, China's first 3-micron 16-K static RAM circuit was produced by the Institute of Microelectronics at Qinghua University. SRAMs are key elements is microcomputers and automated equipment. China Daily, October 26, 1985, p.3.

C. Structure and Organization

Organizationally, the computer industry is dominated by the Ministry of Electronics Industry, which supervises 8 research institutes, 130 manufacturing facilities for computers (83) and peripherals (47), and 13 application units, with a total of 107,000 workers and staff--out of which approximately 16,300 are researchers, technicians and engineers. The MEI has direct administrative control over 17 of the manufacturing units, while

Selected IC R&D and Production Units in China

Name	Location
Dongguang #878 Factory	Beijing
Beijing #2 Semiconductor Factory	Beijing
Beijing #3 Semiconductor Factory	Beijing
Electronics Factory #871	Shaoxing
Lishan Microelectronics Factory	Xian
Shanghai Component Factory #5	Shanghai
Shanghai Radio Factory #14	Shanghai
Shanghai Radio Factory #19	Shanghai
Jiangnan Semiconductor Factory	Wuxi
Tianguang Semiconductor Factory	Gansu
Changzhou Semiconductor Factory	Changzhou
CAS #109 Factory	Beijing
Institute of Metallurgy, CAS	Shanghai
Institute of Semiconductors, CAS	Beijing
Institute of Microelectronics Qinghua University	Beijing
Institute of Microelectronics Fudan University	Shanghai

the remaining ones are under some form of local and/or central control.[13] Within the MEI, direct responsibility for management of computer-related matters belongs to the department of the computer industry, which is the former State Administration for the Computer Industry. (See Chart 1) SACI was originally established in 1979 to unify the management of R&D, production, and marketing of computers on a nationwide scale. It was incorporated into the MEI as part of the May 1982 bureaucratic reforms. The director of the computer department is Liao Yuming.

Along with MEI, several other ministries play a key role in computer development and application. The two most important are the Ministry of Space Industry (space and weapons programs) and the Ministry of Machine-Building Industry (industrial applications). In addition, there are 5 specialized computer institutes within the Chinese Academy of Sciences (e.g. Institute for Computing Technology in Beijing, Institute of Computer Applications in Chengdu, etc.). Their major focus is on basic design, computer architecture and software development. Several of China's major universities also play an important role in computer development, including Qinghua, Beijing, Fudan, and Shanghai Jiaotong.

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[13] Out of the total number of facilities, 19 fall into the category of "large and medium," while 111 fall into the "small" category.

Sitting above these various organizations is the State Council "special leading group for electronics" headed by Vice-Premier Li Peng--which has overall responsibility for developing and coordinating China's national computer strategy. This leading group, which was re-organized in 1984 after a somewhat inauspicious start under the direction of Vice-Premier Wan Li, relies on inputs from key ministerial representatives from the civilian and military sectors as well as an advisory group of about 10-15 computer specialists from leading universities and research institutes around the country.[14] While the leading group does not have a specific budget for project purposes, it works directly with the State Planning Commission to ensure that sufficient funds are available for key projects. Its emergence is highly significant because of its mandate to provide overall policy guidance and cross-ministerial coordination in an industry where both have been severely lacking in the past.

Along with the State Council "leading group," the State Science and Technology Commission, the State Education Commission, and the State Economic Commission also have substantive responsibilities for helping to formulate China's informatics policy and manage the country's computer development. (See Chart 2) These national level organizations are complemented by a series of provincial and municipal commissions and corporations for management of local computer development and applications. Three cities stand out in this regard: Beijing, Tianjin, and Shanghai. Shanghai municipality, for example, has its own "local level" leading group for electronics and computers.[15] In addition, in 1984 the Shanghai Computer Corporation was created as a separate entity under the aegis of the Shanghai Economic Commission to manage computer manufacturing, R&D, software development and applications in the city's various industrial and commercial facilities.[16]

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[14] Denis Simon and Detlef Rehn, "Understanding China's Electronics Industry," China Business Review, March/April 1986.

A number of organizations are involved in the business of managing the PRC's computer imports. One primary organization is the China National Electronics Import and Export Corporation (CEIEC), which is an independent corporation operating within the Ministry of Electronics Industry. The CEIEC has a number of branches throughout the country, e.g. in Shanghai--though its principle role is to act on behalf of MEI and other central ministries. The Ministry of Foreign Economic Relations and Trade, operating through the China National Technology Import Corporation, Instrimpex, and China National Machinery Import-Export Corporation also plays an important role--though its level of activity had diminished in some respects due to trade decentralization and the emergence of import/export firms under the respective functional ministries. Various organizations are involved in importing computers and related equipment for the Chinese military, including the Northern Industries Corporation (NORINCO), Poly-Technologies, Milky Way Company in HK, Xinshidai Corporation, Poly-Technologies, and Great Wall Corporation. For example, NORINCO is now in the process of preparing a plan to import a computer-aided design and manufacturing center for heavy truck development. The Oriental Scientific Instruments Corporation acts on behalf of the Chinese Academy of Sciences as its primary computer import arm.

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[15] A number of ministries also have introduced their own "leading groups" for computer technology, applications, and standards. For example, the Ministry of Railways formed such as group in mid-1983 as part of its efforts to better coordinate and provide guidance for computer utilization. Jisuanji Shijie, #13, July 5, 1983, p.1.

[16] Renmin Ribao, June 29, 1984, p.3.

Interactions among computer users as well as the R&D community involved with computers has been facilitated by the creation of the Chinese Computer Federation in March 1985.
Prior to this date, the CCF was a professional society under the Chinese Institute of Electronics.[17] The aim of the CCF is to develop computer science and technology in China, promote the application of computers, and to stimulate the growth of the local computer industry. The CCF has 11 professional committees, eight professional groups, seven working committees, and an office to handle day-today affairs. As of January 1986 there were over

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[17] See Dianzi Jisuanji Dongtai, #6, 1981, p.64 translated in JPRS 78836, August 26, 1981, pp.1-4.

15,000 members. The CCF has relations with the computer societies of 28 provinces, cities, and municipalities.

D. China's Strategy for Computer Development

China's strategy for developing its computer industry has been an evolving one, heavily influenced by a combination of domestic political as well as technological and economic factors.' In addition, considerations of self-reliance and technological dependence have also played a role in the definition of an overall strategy, though it must be acknowledged that great uncertainty has existed in the past and will continue to exist in the future regarding the balance between foreign imports and indigenous efforts. In early 1982, the Chinese leadership articulated a blueprint for computer development which would catapult China by 1990 to the same technological levels achieved in the advanced developed countries in the early 1980s.[18] This was a very ambitious target given the fact that China's computer design and manufacturing capabilities have been considered by most foreign experts to be 7-10 years behind those of the US and Japan. Total computer output was designed to triple by 1990, reaching an annual production capacity of 1,800 large and medium computers and 40,000 micro and single board computers. The role of foreign technology, although assigned an important place in the strategy, was clearly viewed with a large dose of caution. According to one former MEI official, "our consistent policy is too rely on ourselves, and at the same time learn from the advanced technology of foreign countries. ...if we blindly import[ed] computers, we would have to spend billions of dollars before widespread use of computers in China was achieved."[19]

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[18] The description of these goals was provided by Li Rui, former general manager of the department of computer industry under the MEI. See "Computers in China," Summary of World Broadcasts/Far East (FE/W1201/A/13), November 10, 1982, pp.13-14.

In both 1983 and 1984, major nation-wide conferences were held to further map out the appropriate course for computer development. At the 1983 meeting, a decision was made to give greater emphasis to micro and minicomputers, reflecting the increased appreciation of the potential role of computers in industrial management and production, engineering design, etc.[20] The strongest imperative for progressing ahead in computers, however, began to appear in late 1983 as discussions about the "new global technological revolution" began to sweep China. At a January 1984 symposium sponsored by the China Research Society on the Future, Huan Xiang cited computers and knowledge-intensive industry as the keys to China's ability to catch up with the West.

> "Some new rising industrial countries... are beginning to devote attention to arming themselves with the application of computers. Brazil in South Anerica is doing so. India is also promoting computers as a major component of its national construction planning. South Korea has

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[19] Summary of World Broadcasts/Far East (FE/W1201/A/13), p.14.

[20] "Conference on Computer Development Ends," FBIS PRC, August 13, 1983, K.15.

> also worked out a 10-year development plan for the computer. The computer is developing fast in Singapore. ...Taiwan--a part of China--has concentrated funds on developing microelectronic technology and has founded the Xinzhu Science Area. Hong Kong industrial circles have suggested the founding of a development center for computer technology. **They are all devoting major efforts to developing technology-intensive industries and are engaged in rearranging their economies. This trend cannot but arose our concern and attention.**[21]

At the February 1984 conference, the essential elements of the current computer development strategy began to take shape. Focusing on the last 2 years of the Sixth Five Year Plan, Jiang Zemin, former Minister of the MEI (and currently Mayor of Shanghai), stated the following objectives:

1. "...we will concentrate our efforts on building a technological basis for the microcomputer industry and raise our ability to produce complete equipment. We will energetically develop the production of 8-bit computers, 16-bit computers, and a general system for microcomputers to form several assembly and adjustment lines for microcomputer sets."

2. "...we will energetically raise the percentage of China-made components and parts used for manufacturing microcomputers and focus our attention on making China-made circuit boards."

3. "We will pay close attention to the construction of three computer industrial bases of north China, south China, and east China and to forming combined service bodies for computer research and production to create favorable conditions for rapidly developing the computer industry in the Seventh 5-Year Plan period."

4. "To develop the electronics industry, we should centralize financial and material resources, pay special attention to key points, ...expand foreign economic exchanges, introduce advanced

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[21] Huan Xiang, "Catch Up with the Industrially Advanced Countries," Guangming Ribao, March 2, 1984, p.4 translated in JPRS-CST-85-013, May 1, 1985, pp.10-12.

technology, **and strive to raise our ability to stand on our own feet to blaze a new trail in the electronics industry.**"[22]

For the rest of the decade (1986-1990), China's strategy for developing its computer industry will continue to contain many, if not all, of the points spelled out in 1984. For the most part, China's primary focus is on the linking together of electronics and informatics development. The centrality of this thrust was established in January 1985 in a speech made by Vice-Premier Li Peng.[23] According to Li, the "emphasis of development of the electronics industry will be shifted onto the course of developing microelectronics technology as the foundation and computer and telecommunications equipment as the main body."[24] Li's speech is significant because it reflects the realization among the leadership of two key points: 1)that there is an integral link between the electronics, informatics and communications industries--the latter two which cannot develop without significant progress in the case of the former; and 2)that there must be a greater degree of synergy between indigenous programs and foreign imports.[25] These themes were repeated again by MEI head Li Tieying, in his announcement of the development goals for China's electronics industry in the 7th Five Year Plan.[26]

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[22] "Minister Jiang Zemin on China's Developing Electronics Computer Industry," Zhongguo Xinwen She, February 21, 1984 translated in FBIS PRC, February 28, 1984, pp.K8-9.

[23] Li Peng, "Electronics and Information Industries Should Serve the Four Modernizations," Xinhua, January 13, 1985 translated in FBIS-PRC, January 15, 1985, pp.K20-24.

[24] FBIS-PRC, January 15, 1985, p.K.25.

In terms of specific types of computers, development of microcomputers, which are regarded as the most suitable in terms of prevailing production capabilities and potential applications, will continue to be emphasized. Technologically, the Chinese have been able to develop and produce 8-bit and single board computers, many of which have been modelled upon existing Western machines. They have also been able to develop and manufacture on a limited basis 16-bit microcomputers; here again many of these machines resemble Western equivalents such as the IBM-PC/XT. (In the area of imports, the Chinese have shifted away from purchase of almsot all 8-bit machines and many types of 16-bit computers since they are now able to produce varieties of both machines on their own.)

The development of mainframe computers (and super computers), which experienced serious problems in the past, is now entering a recovery stage in terms of the overall strategic orientation of the industry.[27] This is best exemplified by the attention being given to the 757 computer (10 mips) designed and produced by the Chinese Academy of Sciences and the Galaxy (100 mips) designed and produced by the National Defense S&T University in Changsha, Hunan.[28] A decision was made in late 1985 to designate Beijing, which was chosen over several other cities, including Shanghai, as a special site for mainframe computer development. According to the EDP China Report, an R&D-production complex will be established, built around the following key institutions: The Beijing Wire Communications Factory, the North China Computer Research Institute, the CAS Institute of Computer Technology,

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[25] For an earlier commentary on this latter point see Ge Zhangi, "A Discussion of the Countermeasures of the World's New Technological Revolution and the Foreign Trade of China's Electronics Industry," Guoji Maoyi Wenti, Sept-Oct 1984, pp.6-10 translated in JPRS-CEA-85-004, January 16, 1985, pp.48-55.

[26] Li Tieying, "Continue the Reform, Speed Up the Development, and Actively Invigorate the Electronics Industry," Zhongguo Dianzi Bao, January 21, 1986, p.1. See also Zhongguo Dianzi Bao, December 31, 1985, p.2.

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[27] For an analysis of China's use of computer-aided design techniques to develop large computers see Liu Shenquan, "Use of Computer Aided Design in the Development of a Large Computer," Jisuanji Yanjiu Yu Fazhan (Computer Research and Development), Number 6, March 1983, pp.1-7 translated in JPRS-CST-85-010, April 17, 1985, pp.48-57. Among the limiting factors cited by Liu in the use of advanced CAD techniques in China are poor quality peripherals, the small capacity of magnetic disks, absence of plotters and graphic input devices, and lack of interactive systems.

[28] Based on information obtained in Beijing in January 1986, it appears that at least two (2) Galaxy machines have been built, one that is being used by the Ministry of Petroleum Industry and one that is still in Changsha being used by the PRC defense community.
There also is some evidence to indicate that three other machines have been developed as part of the Galaxy project: 1)Galaxy F1--which is a digital computer for simulation; 2)Galaxy X1--which is a super minicomputer; and 3)Galaxy Yx-21--which is a digital bionic computer (fangsheng jisuanji). Significantly, it was asserted that approximately 90-95% of the integrated circuits and related components used to build the Galaxy were imported from abroad. Similarly, the 757 computer, which initially used a magnetic core disk for memory storage and relied solely on domestic components, is now being re-built using imported integrated circuits for both logic and memory functions. As a result of these improvements, the operational speed of the 757 will be increased from 10 to 30 mips.

Beijing University, Qinghua University, Beijing Computer Industry Corporation, and the Beijing Information Engineering College.[29] The basic orientation in terms of design--which has been dictated by considerations of standardization, software compatibility, and networking needs, will be to emulate Western models produced by such prominent firms as DEC, IBM, and Control Data Corporation. This will ensure that domestic built machines can effectively interface with many, if not most, of the computers that have been imported over the last several years.

Nonetheless, while mainframe development will be given additional capital investment and support, it appears likely that the stress on development of microcomputers will continue during the rest of the 1980s, with increasing emphasis placed on domestic production of both components and complete machines.(Table 2) There is also some evidence of a growing interest in minicomputers because of their price-performance ratio compared to large mainframes. One driving force behind the concentration on microcomputers, and more recently minicomputers, is the shift away from stand alone machines towards more networking both within and between organizations as well as the growing emphasis on application of computers in industrial, management, and office settings.[30] In this regard, China hopes to gradually, though steadily, approach the current breadth of Western uses as well as quality levels and processing capabilities by the 1990s.[31]

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[29] "Beijing Area Chosen to Manufacture Mainframe and Medium-Scale Computers," EDP China Report, Volume 4, November 30, 1985, p.18.

Computer Applications in China

(By the nature of the end-user)

Sector	% of Units
Industry/Transport	61.2%
Science/Education	17.0%
Commerce/Finance	3.4%
Culture/Health	3.4%
Agriculture	2.5%
Other	12.5%

Source: Commercial Section, US Embassy, Beijing, China, 1986.

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[30] In mid-1095, the State Economic Commission inaugurated a program in cooperation with the Chinese Enterprise Management Association to run a series of training courses on computer use for managers and factory directors in 3,000 key industrial firms. "Managers and Directors of 3000 Large and Medium-Sized Enterprises Will Be Trained for Computer Knowledge in June," Jingji Ribao, March 1, 1985, p.1.

[31] For an overview of microcomputers in the West see the special issue of Science, February 28, 1986, pp.935-978. In order ensure quality levels, MEI will require local microcomputer manufacturers to apply for permits before they can produce machines. Each factory must undergo an inspection and pass a certain technical level to qualify for a permit. Each permit will be good for three years. To be considered for a permit, the factory must have a quality control management system, it must be able to certify a MTBF on components of more than 1000 hours, and it must offer maintenance, service and application assistance. EDP China Report, March 15, 1986, ppp.144-145.

Application of Mini & Mainframe Computers in China

Application	% of Units
Artificial Intelligence/CAD	33.2%
Scientific Calculations	20.6%
Data Processing	27.7%
Process Controls	18.5%

Source: Commercial Section, US Embassy, Beijing, China, 1986.

Tianjin is key one city where the current national strategy has been implemented successfully, albeit partially and quite gradually in some cases, and where overall computer development and application appears to have responded well to the directives coming out of Beijing. The rise of the local computer industry has been spearheaded by the R&D work of the Tianjin Institute of Applied Computer Technology, which played an important role in the development of the DJS-153 minicomputer and the Tianjin #2 Radio Factory.[32] With its over 6000 person workforce in the computer industry, Tianjin has been able to popularize the use of microcomputers throughout all facets of industry by responding to end-user needs.[33] For example, in early 1984 the Tianjin Institute successfully trial manufactured the DJS-155-1 digital computer, a ruggedized and improved version of the DJS-153. Because it possesses anti-shock characteristics, it is suitable for installation on ships, in vehicles, etc. In addition, city leaders have been able to use the advances of the industry to overcome local hesitation and lack of knowledge about the use of computers.[34] One major success in this area was the successful application of a microcomputer to the distributor system of the Tianjin #2 Cotton Mill.[35]

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[32] Yang Mingbiao, "Cooperation Between Electronic Computer Institute and Radio Plant #2 on Microcomputer Development and Applications," Tianjin Ribao, November 29, 1983, p.1 translated in JPRS-CST-85-013, May 1, 1985, p.65.

[33] "Tianjin's Popularization of Microcomputers Gains Successes with 632 Sets Used in More than 30 Fields of Industrial Management," Tianjin Ribao, January 10, 1984, p.1 translated in JPRS-CST-85-013, May 1, 1985, pp.60-61.

E. Constraints and Progress in Computer Development and Application

The major constraints in establishing an advanced Chinese computer industry fall into four categories: 1)manufacturing capabilities; 2) peripheral equipment; 3) technical personnel; and 4) software.[36] Techniques for mass production of final products as well as computer computers are severely lacking in China. Even though advanced components are being developed in the laboratory, many factories lack the necessary production equipment and managerial know-how to produce these items in sufficient quantities and at necessary reliability levels. A good example of how these shortcomings can affect the development of a specific machine involves the case of the DJS-186, a 16-bit minicomputer similar to DEC's PDP-11 series. The DJS-186, whose development began in 1978, experienced numerous problems because the delivery of domestic-made ICs did not materialize and imports had to be used instead and continued uncertainty over which factory was going to take over manufacture of the prototype.[37]

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[34] Developments in Tianjin have benefitted from the strong support of the local S&T and economic commissions as well as from exposure to foreign machines and technology. In this latter regard, the Tianjin Institute of Computer Technology utilized Japanese designs as well as the Motorola 68000 microprocessor to develop the TWS 0600 single-board microcomputer. Tianjin Ribao, January 12, 1984, p.1 translated in JPRS-CST-85-013, May 1, 1985, p.79.

[35] "Successful Test Run of a Microcomputerized Distributor," Tianjin Ribao, December 25, 1983, p.2 translated in JPRS-CST 85-013, May 1, 1985, pp.68-69.

[36] Financial constraints are also a problem, though not as serious as in other fields. During the Sixth Five Year Plan, the central government invested 5.0 billion yuan in the computer industry, which constituted 0.9% of the central government's total investment in fixed assets. Approximately US$ 1.0 billion went for computer imports during this same period. China Daily, April

Relatedly, the Chinese remain unable to meet the growing needs of computer users in most facets of peripherals, mainly because they are lacking in both technology and manufacturing capabilities. This is particularly true regarding items such as disk drives, printers, and monitors. For example, while places such as Taiwan and South Korea have been able to push forward on monitor development because of their achievements in black & white/color televisions, China has not been able to rely on such a technological foundation to move ahead in this area.

10, 1986, p.2.

[37] S. Jacobson and Jon Sigurdson, Technological Trends and Challenges in Electronics (Lund, Sweden: Research Policy Institute, 1983), pp.249-289.

In terms of personnel, while the Chinese have set out to train a substantially increased number of computer scientists, engineers, and programmers, the fact remains that they still do not have a broad base pool of experts to support a full-fledged national effort throughout the country.[38] As of the beginning of 1985, there were 89,800 person employed in China's computer industry, 15,300 of which can be described as "technical workers;" by mid-1986 that total number grew to over 107,000.[39]

Training is an important aspect of China's computer development drive. A good example of one of China's better computer science programs is the one at Nanjing University.[40] Initially part of the mathematics department when it was established in 1958, it formally became a department in 1978. There are 54 faculty members in the department: 2 full professors, 7 assistant professors, 37 lecturers, and 8 teaching assistants. As of the early 1980s, there were approximately 600+ undergraduates, 20 postgraduates, and 8 advanced students in the department. In addition, over 800 students from other parts of the university were given training through courses in computer science offered by the department. All together, about 35 courses of instruction are offered. The department has also been steadily involved in national computer development efforts, having completed 13 national and local level projects, eight of which "have filled gaps in China" and six of which have won awards. Through work on these projects, it has formed cooperative relationships with a number of key production units, including the Shanghai #13 Radio Factory, the Changzhou #2 Radio Plant, and the Nanjing #734 Plant. Faculty and students from Nanjing University have been sent abroad to study computer science.

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[38] According to one official at Beijing University, the ratio of software and hardware personnel is 1:4 while in most advanced nations it is 3:1. Chen Yifan, Urgent Need to Train Qualified Personnel for the Computer Industry," Guangming Ribao, March 3, 1984, p.2 translated in JPRS-CST-85-016, May 23, 1985, pp.23-24.

[39] The distribution of the technical workforce is also a problem; over 28,000 of China's computer experts are in Beijing. This number is similar for Shanghai, leaving the rest of China with a severe shortage. China Daily, January 18, 1986, p.2.

[40] Wen Youxin, "Report on Nanjing University's Computer Science Department," Gaojiao Zhanxian, No.4, April 1982, pp.25-26 translated in JPRS 82183, November 8, 1982, pp.57-60.

Programs such as the Computer Science Department at Nanjing University have sprung up through out China's higher education system. The US$200 million education loan given to China by the World Bank in 1982 has helped facilitate the purchase of equipment and the introduction of higher level courses dealing with computer programming, languages, etc. These advanced programs are complemented by a broad based effort to introduce China's younger students at the elementary and high school levels to the role of computers.[41] In both respects, the Chinese have gone far beyond the Soviet Union so far in trying to spread computer literacy throughout the country.[42] Yet, while education programs, including ones such as the computer education project supported by the World Bank and the Beijing Computerland Institute, are a step in the right direction, Chinese officials acknowledge that they still remain inadequate in terms of meeting current and projected future needs for a wide range of computer literate technicians. According to one estimate by an official from the MEI's State Computer Administration, at least 100,000 trained specialists are needed in research and production, while an additional 500,000 will be needed as computer operators by the 1990s.[43]

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[41] Some of these programs are being supported by the local science and technology association. See FBIS-PRC, February 28, 1984, p.P1.

With respect to computer software, substantial progress does appear to have been made in the development of Chinese character input systems as well as software.[44] So far, four primary computer input systems exist for use of Chinese characters: 1)cang jie system (developed in Taiwan and Hong Kong): characters are entered by pressing 1 to 5 English language letters; 2)three corner system (developed at Wang Labs): all characters are reduced to roughly 100 radicals and are entered by typing in codes for each part of the entire character; 3)pinyin system: English letters are used for romanized characters; and 4)dragon system: which is based on telegraphic code numbers that are contained on a large keyboard. PRC computer specialists have developed a number of similar and complementary systems for working with Chinese characters.

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[42] See "Soviets Launch Computer Literacy Drive," Science, January 10, 1986, pp.109-110. Th article reports that high school students in the USSR are being taught computer basics without machines; the Soviet Union has yet to develop and mass produce a serviceable domestic personal computer.

[43] China Daily, April 10, 1986, p.2.

[44] In the case of the former, there are somewhere around 400 different systems in China for inputing Chinese characters. Two interesting approaches using "pinyin" were recently developed by researchers at the Science and Technology Bureau of Nanyang Prefecture in Henan and the Guangzhou Institute of Electronics Technology in Guangdong respectively. China Daily, July 11, 1984.

In mid-1985, for example, a computerized Chinese-language information storage system was introduced by the Beijing Teachers University. It can automatically process any Chinese language information into corresponding key word and phrase data banks, print out lists of word usage frequency, edit, and compile word entry indexes. A national university computer software center was established in Beijing through the Ministry of Education in early 1984 to offer technical services to various local and national level organizations.[45] A few months later in the same year a national software industry association was also established to share information on research projects in the software area.[46]

Relatedly, in late 1983 China's first CAD system for exterior car body design was produced through the joint effort of the Shanghai Tractor and Automobile Research Institute and the

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[45] "Education Ministry Holds Software Conference," FBIS-PRC, March 20, 1984, pp.K17-18.

[46] "Software Industry Association Established," Xinhua, September 6, 1984, p.K18-19.

Institute of Mathematics at Fudan University.[47] And, in early 1986, China's first comprehensive software package called "The Software Package for Modern Digital Signal Processing," was introduced by the Northern Jiaotong University in Xian in conjunction with five other institutes in Beijing, Shanghai, and Xian.[48] The package covers a total of 42 programmes ranging from measurement statistics to modern spectral analysis.

The city of Shanghai clearly has ambitions to become a leader in the development of software and to enter the world market as a key source of computer software.[49] Shanghai Jiaotong University has been particularly adept at introducing all types of new and improved software into the Chinese market.[50] Shanghai's strategy is to rely on a)its abundant labor force, b)its strong S&T and education base, and c) the availability of transport and communication capabilities to produce a low cost package of software.[51] And consistent with this objective, the Software AG

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[47] "China's First CAD System for Car Body," Jiefang Ribao, October 20, 1983, p.2 translated in JPRS-CST-85-038, November 5, 1985, p.68.

[48] "Software and Money Aid Science," China Daily, April 11, 1986.

[49] Madelline Ross, "Shanghai's Push Into High Technology," China Business Review, March/April 1985, pp.36-39.

[50] See Shanghai Academy of Social Sciences, ed., Shanghai Jingji Fazhan Zhanlue Wenti (Shanghai: Academy of Social Sciences Publishing House, 19840, pp.133-142.

[51] See "There Are Bright Prospects for Shanghai's Software Exports," Shijie Jingji Daobao, May 23, 1983, p.10.

Inc of Tokyo has been negotiating with the Shanghai Institute of Computer Technology to work with a Chinese counterpart on software development and exports.[52]

However, as in the past, the problem of "generalizability" continues to be widespread as a significant percentage of the software being developed still tends to be machine-specific. In the past, software development was considered to be the "achilles heel" of Chinese computer development. Today, the introduction of several central government standards for software development[53] as well as the appearance of various organizations such as the China Software Corporation and the China Computer Users Association will help remedy a large number of these problems.[54] The latter organization, which was formed in March 1983, has numerous branches throughout the country.[55]

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[52] Japan Economic Journal, July 31, 1984, p.15.

[53] As of early 1985 there were between 100-400 Chinese input systems under development in China. The State Council has set up a special committee to "boil down the massive, often disparate work into a unified system for industrial production." China Daily, Business Weekly, January 29, 1985, p.2. See also China Daily, May 23, 1985.

[54] A good example of Chinese progress was the recent development of HCDOS, a Chinese-English operating system that runs on the IBM 5550. The 5550 is a multi-function microcomputer that can handle Chinese character inputs. (The Chinese would like to eventually manufacture in Guangzhou under the Huanan (East China) Computer Corporation.) The operating system was developed by the Institute of Computer Applications Research at Hunan University and a computer company in Changsha. All of the original software for the IBM PC and the 5550 can still operate using HCDOS.

[55] See FBIS-PRC, March 29, 1983, p.K7.

In spite of the proliferation of computers, under-utilization remains a serious and widespread problem. The investment made in the development of application systems is unproportional to that made in the development or import of basic systems. According to an EDP China report, "...users are usually only willing to pay for hardware and hand out money almost grudgingly for software. The importance of researching and designing application systems is not yet widely recognized." [56] The problem is particularly acute regarding domestic made machines. In fact, many questions remain about the future of existing lines of domestic computers, such as the DJS-100 series because of the realization that many of these machines do not meet international standards in terms of quality, type of operation, and/or software compatibility.[57]

According to sources in Beijing, 32,000 microcomputers were manufactured in 1985, while there were still 40,000 stocked in warehouses with no customers in sight.[58] In addition, officials in the computer industry have suggested that in Beijing municipality, for example, the utilization rate of installed microcomputers is only 26%, while the national average is in the range of 15-20%.[59] The problem of poor utilization has its roots in personnel shortages, though other key factors include organizational rivalry and intense bureaucratic jealousy,[60] poor maintenance, limited software availability, and poor after-sales service.[61] One estimate suggests that the Chinese will waste between US$20-$85 million over the next three years because of improper use and maintenance of imported computers.[62] In some cases, enterprises have been "ordered" to have a computer without having the personnel to operate it or any idea about how to best put the machine to use.[63] These problems hold true to both domestic made and foreign imported computers.[64]

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[56] EDP China Report, Volume 4, June 17, 1986, p.242.

[57] As suggested earlier, the DJS-200 has already officially been discontinued as of 1981-82.

[58] "Computers Facing Glut in Market," China Daily, January 11, 1986, p.3. One source suggests that the number of stockpiled microcomputers has decreased to 18,000 by January 1986. China Daily, April 10, 1986, p.2.

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[59] According to one source, a survey of 14,000 microcomputers in place in Beijing revealed that most are used less than three hours of day. "Beijing Has Future as Computer Capital," China Daily, January 18, 1986, p.2.

[60] See the case of the wrangling among the Kaifeng Computer Center, the local telephone bureau, and the Kaifeng #3 Hospital in Henan province to appreciate the extent to which organizational rivalry plays a role in China. China Daily, April 7, 1984, p.3.

[61] There are approximately only 10,000 people involved in computer services in China. The creation of the China Computer Services Corporation in 1984 to handle 6 main functions: systems integration, technical training, data processing services, database supply, software development, and specialized services and consultation, is a positive step toward improving computer usage, though the numbers of people and their skill levels remain inadequate. Chen Liwei, "The Position and Role of Computer Services in the Computer Industry," Dianzi Xuebao, #5, September 1984, pp.65-67 translated in JPRS-CST-85-009, April 9, 1985, pp.57-61.

[62] Sam Howe, "China's High Tech Troubles," New York Times, May 5, 1985, p.F9.

Political problems can also be pervasive in the computer industry. At the Hunan Provincial Computer Center, eight persons had to be dismissed from their posts because they lacked the skills to handle their particular assignments.[65] The Hunan center is one of the key links in China's national computer network; its responsibilities include collecting, processing, storage, and exchange of economic information within and outside the province.[66] Through a "network of personal connections," high level cadres used their positions to secure jobs for their relatives and children. The center became known as "a home for the lazy."[67] At one point, of the 39 children of leading cadres above the rank of department directors, more than 60% (24 persons) knew little or nothing about computers. After numerous problems, the situation was brought to the attention of the provincial party committee for resolution.

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[63] "Problem of Idle Computers," China Daily, April 3, 1985.

[64] For a rather critical assessment of China's computer industry see Cary Lu, "China's Emerging Micro Industry," High Technology, March 1985, pp.69-70. Lu cites lack of access and understanding of software, a dearth of qualified personnel, high costs, language problems, etc. as factors that have slowed down computer development and application.

[65] "Hunan Set to Curb Irregular Recruiting," China Daily, April 5, 1984.

[66] The center was completed in 1982. See FBIS-PRC, July 22, 1982, p.P6.

[67] China Daily, May 11, 1984, p.3.

Even though the above-mentioned utilization problems are pervasive, the fact remains that use of computers has spread throughout the economy and society. According to an official from the MEI, there were about 100 types of uses for computers in 1980 (with most computers being used for calculations), while as of mid-1985 there were 15,000 uses.[68] The Chinese have even gone so far as to establish a computer dating service! In many cases, computers have been introduced in the form of industrial control systems, such as in the Ministry of Machine-Building Industry (MMBI), where work on automation has rapidly proceeded forward over the last two years. There is a computer research center in the MMBI that has as its principle function the expanded introduction of CAD/CAM technologies--though some of its efforts are being held back by the lack of specialized components from MEI to support its development efforts.[69]

Most important, the drive to introduce computers into industry and society has stimulated expanded interactions among computer manufacturers and potential end-users. Given the gap that has often existed between developers and users in China, this trend could be highly significant. For example, the Shaoguan Radio Factory in Guangdong, which is a leading manufacturer of 8-bit and 16-bit microcomputers in South China, has transferred a number of its engineers and skilled workers to form an outreach/sales team for the promotion of microcomputer use.[70] In addition, the factory has instituted user training classes, a lecture series, etc.

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[68] "Computer Production Must Follow Demand," China Daily, April 10, 1986, p.2.

[69] In some cases, because of the nature of prevailing export controls, the Chinese have been able to purchase the hardware for CAD work, but have been blocked from buying the accompanying software--a situation which has, on the one hand, fostered poor utilization of imported equipment, but on the other hand, has stimulated indigenous software development efforts.

China also has plans to boost development efforts in robotics--which is still in its infancy in comparison with similar efforts in Japan and the US.[71] The Seventh 5 Year Plan contains provisions for the manufacture of industrial robots for paint spraying, point and arc welding, and cargo carrying.[72] As of the end of 1985, China had more than 100 industrial robots and 1000 mechanical hands in place.[73] Among China's 20 robot research institutes and development centers, the Institute of Automation of the CAS in Shenyang will be the site of a major robotics research and development center.

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[70] Nanfang Ribao, March 4, 1984, p.2 translated in JPRS-CST-85-014, May 2, 1985, pp.40-41.

[71] Zhang Chunfen, "Development of Industrial Robots for the Aviation Industry," Hangkong Zhizao Gongcheng, #5, May 1, 1985, pp.2-4 translated in JPRS-CST-86-001, January 17, 1986, pp.60-63.

[72] "Robots Set To Receive Boost in Development," China Daily, February 1, 1986, p.1.

[73] China Daily, November 13, 1985.

Among the successful examples of effective application of computers are the following: a)establishment of a computer based flood warning system under the Ministry of Ministry of Water Conservancy and Electric Power; b)formation of a computer center under the People's Bank to manage financial transactions; c)application of computer controls to boiler operation in thermal power stations in Guizhou province; d)safety analysis in power plants; e)social science data storage and analysis in the Chinese Academy of Social Sciences; f)establishment of a computer center at the Daqing Oilfield to handle prospecting information and research work; and g)computer-aided architectural design, especially concerning earthquake-proof construction.[74] Significantly, the Communist Party has also gotten caught up in China's computer revolution; the provincial party office in Shaanxi, with the help of the Lishan Microelectronics Company, has introduced a computer system for general management tasks. Thus, while problems abound, China has gone much further than, for example, the USSR in allowing the roots of the new information society to take hold.[75]

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[74] Along with industry-oriented applications, the first computer station in rural China was set up in mid-1984 outside of Beijing. The computer station, which is run by a local township in Beijing municipality, is responsible for calculating the temperatures needed for growth of all sorts of plants, figuring out appropriate planting densities, determining adequate water allocations for irrigation purposes, and calculating fertilizer needs and applications. It will also perform accounting tasks for the rural industry and a host of other scientific calculations regarding the amount of light and humidity needed by plants in local greenhouses.

One area where some rather interesting work has already been done deals with the attempt to establish a nationwide economic and S&T information network linked through the China National Science and Technology Center in Beijing.[76] A number of the key coastal cities (10) along with the Institute for Scientific and Technical Information (ISTIC) under the SSTC are the key organizations involved.[77] The Chinese are attempting to draw upon Western data bases as well as create their own data retrieval systems.[78] Progress, however, has been impeded by China's poor communications infrastructure, which have added a large element of insecurity and unreliability into the process of data transfer and computer communication. By early 1985, for example, there were only 0.5 telephones per every 100 persons in China. Recent improvements in communications, obtained primarily through technology and equipment imports, may help alleviate some of these problems in the near future. For the present, however, the existence of local area networks as well as distributed processing remains the exception rather than the rule.[79]

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[75] Loren Graham, "Science and Computers in Soviet Society," in Erik Hoffmann, ed., The Soviet Union in the 1980s (New York: Academy of Political Science, 19840, pp.124-134. The Chinese have gone so far as to establish a computer leasing and financing service to promote interest in computers. In 1984, the China Bank of Industry and Commerce in Shanghai opened a leasing agency for those enterprises and government agencies that do not have sufficient funds to purchase computers.

[76] "Information Center Construction Starts," China Daily, September 24, 1984, p.3.

[77] According to Wang Tingjiong, director of ISTIC, there are more than 60,000 people engaged in information collection, dissemination, and services. China Daily, April 2, 1986.

[78] "Nationwide Information Network Planned," China Daily, January 24, 1984, p.1.

Summarizing, the problems of computer development and use in China are being attacked from a multitude of directions. Component manufacture is being given highest priority as the Chinese seek to minimize their dependence on foreign sources for both components and final products, especially in the microcomputer area. Nonetheless, the emphasis on acquisition of computer manufacturing technology will persist, with a growing emphasis on minicomputers. Greater centralized control seems to be emerging as the need for standardization and quality control has been recognized. Application problems remain and there is an insufficient number of qualified personnel on both the development and applications side. Thus, while substantial progress has been, it remains unlikely, with some exceptions, that China will meet its goal of attaining overall by 1990, Western technological and utilization levels of the 1980s in the field of computers.

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[79] One important exception in this regard was China's ability to create a workable computer network throughout portions of the country to store and process data for the 1982 national census. "Counting to a Billion," Datamation, March 1983, pp.183-185. Another exception is the LAN that has been planned for the Ministry of Electronics Industry. See Fan Xitian, et.al., "The MEI Organizational Management Network System," Dianzi Jishu Yingyong, #2, February 25, 1985, pp.6-8.

F. Role of Foreign Computer Imports and Technology

> "Since importing was emphasized in the 1980s, China's computer industry has suffered a great blow. Importing is a correct policy, but how to organize imports properly has not been resolved very well. Any unit can now arrange for its own imports, but what is being imported is mostly equipment, not technology. This is not only wasteful, it also hits domestic industrial production and scientific research work hard. Computer plants are now worried about their own production, since the more they produce the more they loose money... In contrast, they make a lot of money by selling imported machines either with a changed outside appearance or by selling them as soon as they are imported... There is a policy problem here."[80]

In the attempt to modernize their computer industry as rapidly as possible, the Chinese have continued to emphasize the import of technology and computers from abroad. Reliance on foreign ideas and know is nothing new as far as China's computer development is concerned.[81] Beginning with the initial start-up of the industry in the 1950s, China relied on Soviet technical specification to launch its own domestic development program and, as indicated earlier, utilized IBM designs to initiate the DJS-200 series in the 1970s. In addition, foreign technical literature and data regarding computers and electronics has continued to flow into China throughout the last two decades--continuing even during the Cultural Revolution.[82] Moreover, during visits to any number of Chinese universities and research institutes, it quickly becomes apparent that there is no dearth of information or journals regarding computer development in the West. Were it not for the availability of these published materials, as well as China's increased access to Western hardware since 1978, it is likely that computer developnment would have been even further delayed and even distorted.

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[80] "How to Develop China's Computer Industry," Guangming Ribao, April 2, 1984, p.2 translated in JPRS-CST-85-016, May 23, 1985, pp.19-20.

[81] Two things, however, should be remembered in this context. First, electronics has been intimately caught up in the symbolic aspects of China's political debates over the last several years, and therefore, by implication, computer development has been highly politicized. Second, willingness to use foreign technology to advance indigenous computer development has not meant total acceptance. In many cases, local adaptations were introduced, e.g. as part of the policy of sinicization, which in many cases did little to enhance performance and frequently created operational and compatibility problems.

According to comments by Chinese officials in the MEI, foreign computer companies that introduce sophisticated technology and management skills, will be allowed a share of China's domestic market.[83] This policy was introduced, in all likelihood, because proportional to overall equipment imports, very little computer-related technology in disembodied form has flowed into the PRC over the last several years. Within China, in some cases, a tension has arisen between those who are potential end-users and want access to a computer immediately and those who believe that excessive imports should be controlled so that domestic technological capabilities can be allowed to develop. This debate, which is reflected in the above comments by a computer engineer at the Tianjin Computer Factory, has been particularly acute with respect to microcomputers. Between 1981-1985, excessive imports of foreign microcomputers basically undermined the effort to create a viable domestic base.[84] More specifically, so-called "development efforts" were actually limited to assembly of imported SKD (semi-knock down) and CKD (completely knocked down) kits.[85] This brought in large amounts of revenue to those doing the assembly operations because of the great demand for foreign made personal computers, but did little to stimulate indigenous technological progress.[86]

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[82] Personal communication in Chongqing, March 1985.

[83] "Computer Market Opening to Foreign Manufacturers," China Daily, September 7, 1984, p.1. See also "Market for Computers Opened to Foreigners," China Daily, September 6, 1984.

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[84] In 1981, 36% of all microcomputers sold in China were domestically made. Due to the policy of tightening up in mid-1984, that number jumped to 56% in 1985. Of course, the term "made in China" is somewhat ambiguous, since assembly of foreign computers can be included in this category. Nonetheless, it does reflect a growing tendency towards encouragement of local computer products. China Daily, April 10, 1986, p.2.

[85] Assembly of imported computer kits became financially feasible because the duties on imported components were less than the duty on imported computers. Also, both Fujian and Guangdong had initially been exempted from needing to acquire an import license, thus making its easier for persons in both these provinces to broker what came to be called "instant knock-down" computers from Hong Kong, etc.

[86] In some cases, however, indigenous programs for microcomputer development did move forward. For example, the Jinzhou Electronic Computer Factory, Qinghua University, and the 2nd Branch of the Beijing Institute of Technology jointly developed and manufactured the DJS-142, a mini, all-purpose digital computer. The machine can be configured with floppy disk or with a 5-to-20 MB hard disk storage system. While not up to technological levels in the industrialized nations, this machine represents China's continuing effort to develop its own hardware. According to Chinese sources, its operating system supports COBOL as well as BASIC computer languages.

As a result, computers are on the list of 45 items requiring an import license issued by the Ministry of Foreign Economic Relations and Trade.[87] In some respects, Chinese officials in the computer industry see China's development alternatives as lying somewhere between the "self-reliance-oriented" approaches of Brazil and India and the import and imitation-oriented strategy of South Korea and Taiwan.[88] In the case of the former, strong protectionist policies were imposed as a means to moderate foreign competition and pressures foreign firms to provide technology in return for greater market access. In the case of the latter, foreign models have been used for imitation and copying; firms in these two sites have seen linkages with foreign firms as a way to get into the computer industry rather than as a threat to indigenous development.[89] Based on discussions in China and a number of recent articles in the Chinese press, there appears to be a growing trend towards greater "selectivity" and elements of "protectionism" in terms of computer imports, especially in the microcomputer area. This movement does suggest that in some respects the Chinese may be orienting themselves more towards the India/Brazil approach--even in spite of the fact that both countries have experienced problems because of their strict controls.[90] This tightening up over imports, however, while addressing fundamental concerns among the leadership about technological dependency, still takes place in an environment where people tend to denigrate the quality of Chinese-made machines.[91]

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[87] "Ministry Adds 15 Items to Import Licensing List," China Daily, March 5, 1986, p.3.

[88] See Francis Rushing and Carol G. Brown, eds., National Policies for Developing High Technology Industries: International Comparisons (Boulder: Westview Press, 1986).

[89] Even if China pursues the path of imitation and copying, it will require a substantial improvement in its microelectronics capabilities as well as further progress in the use of computer aided design and manufacturing techniques.

China's computer specialists hope that the appearance of the Great Wall 0520 microcomputer can represent the first step in building a more credible domestic computer industry.[92] Basically an IBM-PC/XT clone using US, Japanese, and South Korean components, the Great Wall is produced at three factories in China, the premier one being the Beijing Wire Communications Factory (along with factories in Sichuan and Shandong provinces) which accounted for half of total production and has a capacity to manufacture 10,000 a year. The 0520 series includes three models in order to respond to specialized user needs in engineering design, scientific research, and factory management.[93] The Great

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[90] The tradeoffs are discussed in Rushing and Brown, eds., National Policies for Developing High Technology Industries.

[91] In order to improve the competitive position of domestic made machines, the Chinese recently dropped the prices of indigenously-manufactured models--which heretofore had been considerably more expensive than imported machines (even including import duties) in terms of their price/performance ratio.

[92] "Great Wall Towers Over Domestic Sales," China Daily, Business Weekly, April 2, 1986, p.2.

[93] The MEI has established a "0520 Microcomputer Task Force" to handle sales as well as maintenance, service, and the publishing of materials. The group will work with the China

Wall 0520A uses the Intel 8088 16-bit microprocessor, has a storage of 512 kilobytes and a high resolution color display of 640x200.

It also features a Chinese character disk operating system and is readily supported by a wide variety of Chinese character and IBM software, a factor that makes it more attractive then previous machines.[94] Moreover, to encourage its acceptance in China, the SACI of MEI established an 0520 computer software development consortium; it has signed contracts with over 20 units for over 50 software-related tasks.[95] The main difference from the IBM/PC/XT is that the main board has two serial ports and one parallel port, thus giving the 0520 improved performance characteristics.[96] According to the manager of the computer

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Computer Technology Service Corporation, which will handle training and general sales. The members of the group include the Beijing Wire Communications Factory, the Shanghai Computer Corporation, the Fujian Computer Corporation, the Huabei Terminal Equipment Company, the Suzhou Computer Plant, the 6th Bureau of the MEI and Qinghua University as well as such peripheral manufacturers as the Jiannan Machinery Plant and the Nanjing Wire Communications Plant. Jisuanji Shijie, #7, April 8, 1984, p.1.

[94] China has introduced the Great Wall into the US in the hopes of eventually exporting these machines into the US market. However, while the press in China hailed the success of the Great Wall microcomputer at a recent US computer show, many questions remain about the extent of real compatibility with the IBM machines.

[95] "0520 Microcomputer Software Takes the Path of Joint Development," Jisuanji Shijie, #9, May 8, 1984, p.1.

[96] "Briefing on the ChangCheng 0520 Microcomputer," Dianzi Jishu Yingyong, January 25, 1985, pp.12-14 translated in JPRS-CST-85-027, August 22, 1985, pp.99-105.

division of the Beijing plant, close to 5,000 machines were sold in 1985 and demand is expected to reach 20,000 in 1986. The average cost per machine is 25,000 yuan, which is about 2/3 the price of an imported IBM personal computer.[97]

The concern about the slow progress in indigenous computer development has meant that the PRC has no real alternative in the short-term but to rely on technology transfer as a means to stimulate more rapid and sustained domestic progress. China's key focus, however, is on the acquisition of foreign computer design and manufacturing know-how rather than on the purchase of a large number of foreign-produced machines. Technology acquisition--as opposed to equipment acquisition--is being strongly encouraged because it is viewed as an intermediate step on the way to avoiding long-term dependence on external sources for foreign computers and eventually foreign technology. A good example of a project consistent with Chinese objectives involves the import of a disk drive production line from France in mid-1984 by the Jiannan Electronic Equipment Factory in Hunan.[98] (The line which was the first peripheral production line imported in China, has the capacity of to produce 500 Model ZPC-204 hard disk drives and 3000 ZPC-3 floppy disk drives.) Another involves the 10 year,

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[97] "Ministry Cuts Prices of PRC-made Computers," Xinhua, June 28, 1984 translated in JPRS-CST-85-012, April 23, 1985, p.64. Prior to mid-1984, the price of the Great Wall was 36,000 yuan.

[98] "MEI's Computer Bureau Sets Up First Modernized Disk Drive Production Line," Jisuanji Shijie, #11, June 8, 1984, p.1.

US$12 million licensing agreement between the Gould Corporation and the Tianjin Automation & Instrumentation Factory concluded in late 1984 for assembly and manufacture of dedicated industrial computers called programme controllers.[99] Under the agreement Gould will provide technical training to include instruction in manufacturing techniques, testing operations, quality control processes, and equipment maintenance.

Even in the area of large mainframe development, where appreciable numbers of imports are likely to continue for a while, it is clear that the Chinese are continuing to use Western designs as part of their overall design efforts. R&D programs at MEI's two leading research institutes, the Huabei Computer Research Institute in Beijing and the Huadong Computer Research Institute in Shanghai, are already engaged in following this strategy in terms of their own development efforts. According to one MEI official, "computer technology development should be guided by the principle of standardization, serialization, and universalization. The chosen models should use successful varieties available elsewhere in the world for reference and should absorb matured experience."

This perspective is quite consistent with Chinese practice since the 1970s, when the IBM 360 series was used as a model for the Chinese DJS-200 series--though as indicated the performance of these machines never attained IBM levels due to architecture and software problems. In order to gain access to technology, the Chinese have signed a number of joint venture-type agreements with firms such as IBM, Burroughs, and Hewlett Packard.[100] China's expectation is that its relationship with these foreign firms will evolve away from just sales and distribution, and eventually include provisions to manufacture computers and related components.[101] In fact, given the recent concerns about excessive imports and the newly added duties on such imports, foreign firms will increasingly find themselves faced with no viable alternative but manufacturing-oriented joint ventures or licensing of their technology if they want to sell microcomputers (16-bit) into the Chinese market.

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[99] "Chinese and US in Computer Deal," China Daily, July 12, 1984, p.2.

Sending students, scholars, and technical experts abroad for formal training is a major part of China's strategy for building a modern computer industry. Persons are being sent to places such as MIT, Carnegie-Mellon, Cal Tech, Stanford, etc. to learn the latest thinking in the West about computer design and architecture. In addition, groups of Chinese engineers are being sent overseas for training as part of the equipment purchase agreement.[102] Unlike Taiwan, most of these visitors have returned or will return to China. In some cases, individuals have come with very specific objectives in mind, e.g. computer memory development or a software enhancement--making its highly likely that when they return to China they will be able to easily apply their newly garnered information--a situation that stands in sharp contrast to the cases of other students/scholars who come to the US with somewhat more vague goals. Over the long term, it is this group of visiting scholars in the computer field that will form the technological backbone of the industry.

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[100] At this time, IBM appears to be the most active among the US firms who are trying to expand their computer sales in China. IBM has made the most extensive commitment to the Chinese market, with 13 authorized dealers throughout the country as of the end of 1985.

[101] According to one Chinese commentator at the CAS, "it is difficult to solve the problem of compatibility with foreign computers. Thus, one good way of producing compatible computers is by entering into joint ventures with foreign countries." Wang Xinggang, "Ideas on Developing Computers in Our Country," Ziran Bianzhengfa Tongxun (Journal of the Dialectics of Nature), Number 6, 1982, pp.3-5.

The desire to focus attention on indigenous development does not mean that China has lost interest in importing foreign computers. (See Table 1) Over the next 3-5 years, the demands of economic and military modernization will necessitate continued import of computers, especially, as indicated, in the mini and mainframe range. US sales of computers and related automated data processing equipment rose from US$50 million in 1983, to US$101 million in 1984 and US$187 million in 1985. (According to the

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[102] For example, 45 engineers were sent by the Ministry of Water Resources and Electric Power to complete a three month training course on the VAX 11/750 at Digital Equipment Corporation. The training was conducted in Chinese and administered through Sun Associates, a Chinese-American company active in China trade. China Daily, July 3, 1985, p.2.

Department of Commerce, US-China trade totalled US$7.1 billion in 1985; computer-related sales as a % of total US exports to China accounted for only about 5.4% of total US sales to the PRC) (See Table 2) A visit through a variety of industrial and research facilities reveals a plethora of foreign made computers, and while US-made machines appear prevalent, the stock of computers includes an appreciable number from Taiwan (Multitech) as well as others (some US made) that clearly were clandestinely brought into the country via Hong Kong prior to the relaxation of US export controls and COCOM controls.

China's problem, however, is that even as gains expanded access to more sophsiticated equipment and higher levels of technology, it continues to be plagued by ineffeciency and ineffectiveness when it comes to the assimilation of foreign technology and know-how. Reverse-engineering with respect to computers is a difficult process, especially if a country lacks the capabilities to manufacture the needed components at required levels of quality and reliability on a consistent and continuous basis. And, even if these Chinese can secure needed components from abroad, there is little evidence heretofore, except perhaps for the Galaxy, that they have been able to take that critical step into the world of design, adaptation and innovation on their own. As one Chinese author recently stated in addressing China's penchant for buying equipment and ignoring technology, "let us change as soon as possible the formula of °the first machine being imported, the second machine being imported, and the third machine also being imported' into one of 'the first machine being imported, the second machine being made by China, and the third machine being exported."[103] For China, this will be more easily said than done until the 1990s.

G. Foreign Competition in the China Computer Market (Table 6)

Competition for an increased share of China's computer market is likely to grow in the immediate future as US firms will encounter stiff competition from Japan (Fujitsu, NEC and Hitachi), West Germany (Siemens and Nixdorf), and France (Sofrecom). France (Sems Company), for example, gained lots of political capital when it installed China's first imported computer production line in September 1983 in Guangzhou for manufacture of the "Suola-16 minicomputer.[104] Close business-government cooperation in the case of the Japanese and West Europeans will foster their competitive positions in the Chinese market.

Of these three, however, it should come as no surprise that the Japanese have been and will continue to be the most aggressive and difficult competitors.[105] It is already clear that during the mid-to-late 1970s, Hitachi benefitted (and US firms such as IBM suffered) from the more rapid normalization of relations between China and Japan. The so-called "China strategies" of Japan's computer companies have and will continue to stress training, cooperative software development, special financing packages, and service in order to obtain a competitive advantage.[106]

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[103] "Guangming Ribao Discusses Overreliance on Imported Technology," Zhongguo Xinwen She, July 4, 1985 translated in JPRS-CEA-85-072, August 9, 1985, p.9.

[104] "Installation of Sino-French Computer Production Line Noted," Guangzhou Ribao, October 30, 1982, p.1 translated in JPRS 82905, February 18, 1983, p.31.

Firms such as NEC, Fujitsu and Hitachi have already made substantial strides in developing potential product loyalty through their high profile market position as well as the creation of special training and software centers in China and Japan.[107]

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[105] This is not to suggest that other countries will lag far behind. France, in particular, has been aggressively pursuing computer-related sales in China. Along with the Jiannan project mentioned earlier, they have also sold a production line for manufacture of the "Suola-16" minicomputer to the Huanan (South China) Computer Corporation in Guangzhou. The project, which was funded by both local and central government authorities, involves the coming together of a number of key computer production units under MEI in the Guangzhou area.

[106] Some US firms have chosen to market their computers and related products through their Japanese subsidiaries. For example, Honeywell and its Japanese affiliate (Yamatake-Honeywell), recently signed an agreement for process control technology that includes training in Japan, the US and China. IBM, through its Japanese marketing agent in Japan (Kanematsu Gosho Ltd), is also relying on its Japanese links to penetrate the Chinese market. Kanematsu is one of 13 IBM agents in China. It will concentrate its activities in southern China, particularly in the Shenzhen economic zone. China Daily, February 19, 1985.

[107] For example, a Sino-Japanese Software Center was established in 1982 between NEC and the China Computer Technical Service Corporation of the MEI. The center provides machine time for computer users and accepts computational tasks, designs software systems, and demonstrates various computer products. Jisuanji Shijie, #5, March 5, 1982. NEC also negotiated an

An agreement for joint development of software signed in mid-1983 between the Japan Software Industry Association and the China Science and Technology Exchange Center of the SSTC will also help facilitate the marketing and sale of Japanese computer products.[108] Japanese firms also have been quick to take advantage of changes in the structure of COCOM, such as the recent sale by Hitachi to the People's Bank of China of what can be considered the biggest order for large mainframes computers by China (US$25-30 million).[109]

PRC officials in Shanghai have indicated that they are looking to Japan for guidance on the formulation of an overarching strategy upon which to pattern future development of the country's computer and electronics industry, e.g. Japan's "white paper" on electronics and machine-building industries in the 1950s--which laid the basis for its movement into the area of "mechatronics." Thus, while the Chinese remain leery about

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agreement in 1985 with the CEIEC and the North China Terminal Equipment Corporation to produce 16-bit microcomputers in the latter's Baoding facility in Hebei. FBIS-PRC, February 6, 1985, p.D3.

[108] "Japanese Computer Software Group Feted in Beijing," Xinhua, July 25, 1983 translated in FBIS-PRC, July 26, 1983, p.D3.

[109] Financial Times, February 14, 1986, p.5. The Hitachi deal is important because it could help promote significant sales of additional Hitachi computer products to other banks in China. Some US computer firms believe that Hitachi attempted to take advantage of the pending relaxation in COCOM controls in late 1985. By setting up the sale prior to the COCOM announcement, Hitachi could complete the sale if the appropriate changes were made (which it did) or if the sale could not go through, it could blame the US for blocking the sale.

excessive dependence on Japan, the Japanese experience and thinking will continue to exert a certain influence on China's own development pattern. At the same, it is also true that if US companies offer the "right" combination of training, technology transfer, and financing, they can take advantage of China's apparent "political" preference for dealing with the US.[110] (See cases below.)

The concerns among US firms that they have been loosing sales to China because of prevailing export control restrictions seem to have been largely resolved as a result of the December 1985 relaxation in both US and COCOM controls. (See Table 5) Under these new guidelines, China will have access to a substantial array of advanced computing machinery and related equipment. While it is true that some delays continue to exist in the processing of applications, the fact is that recent changes (manifested in the identification of 27 categories of items designated for liberalized treatment) have greatly improved the process by which applications for licenses are reviewed and acted upon.

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[110] Among some of the US firms that have focused on training are the following: a)IBM, which set up a training institute in Beijing as part of its sales of the IBM 5550 and other machines; b)Wang Laboratories, which set up a joint development center with the Hubei Radio Factory and a service center in Beijing; c)INTEL, which is working with the Computer Bureau of the MEI on establishment of a training center for 500-700 persons in Beijing; and d)Sperry, which is working with the China Computer Technical Services Corporation to train Chinese operators on Sperry equipment.

Yet, while controls on computer hardware have been relaxed, many firms still feel that controls on software exports remain overly restrictive. This is particularly true regarding the software for computer networking, which China badly needs if it is to make effective use of its increasing numbers of computers. In addition, software for CAD/CAM/CAE/ and CAT also remains tightly controlled in the eyes of many US firms. According to interviews conducted in China and the US, the problem of excessive control over software exports must be resolved if US firms are to make significant inroads into the Chinese computer market.[111]

Two Brief Examples of US Computer Firms in China

IBM's approach to the China market seems to stand out among US firms. Each year since 1980, IBM has been able to sell 20-25 mainframe systems to China. In addition, several thousand IBM personal microcomputers have made their way into China, some through direct sales, but a large number through the "gray market." IBM also has set up a training facility in China to support its sales--past, present, and future. In many respects, IBM's success in the PRC has had much to do with the fact that

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[111] The problems with controls on software exports are followed closely by the fact that China's patent law, which was approved in April 1985, does not cover protection of software. Questions remain about how a firm can protect its proprietary software, and whether or not the PRC government will commit to the use of either a copyright law or its patent law to provide greater security to foreign firms that bring their software into China.

Chinese computer officials have considered IBM products (along with the DEC VAX series) to be one of the standards upon which to develop their own indigenous computer industry.

In 1984, IBM China was established. This gave IBM a formal Chinese presence and signalled to the PRC government that IBM was making a long term commitment to China. In the same year, through its subsidiary in Japan, IBM introduced the Model 5550 to China, a multifunction, Chinese language large microcomputer that was well received. The machine is attractive to the Chinese not only because of its ability to efficiently handle Chinese characters, but also because its processing capabilities and performance are far and above any comparable machine produced by China on a mass production basis. In early 1985, IBM donated 100 of the machines to four Chinese universities: Beijing University, Qinghua University, Fudan University and Shanghai Jiaotong University. In May, IBM began training classes for 40 teachers and students to operate the computers. By the end of summer 1986, IBM introduced 3 new models of the 5550 series, all of which offered the same or greater storage capacity while selling at up to 30% less than the original Model 5550. Chinese officials would like IBM to enter into a joint venture to manufacture the 5550 in China. The idea of entering into such a joint venture runs counter to IBM's general approach in the past to international marketing. Nonetheless, negotiations are continuing at this time.

Another example of a US firm that has been increasingly successful in China is Wang Laboratories, Inc. Wang began doing business in China as early as 1972, though its business in the PRC did not really take off until 1978-79. According to the China Daily, Wang has sold more than 200 small and medium-sized computers in China, most of which have been handled through its sales agreement with Instrimpex. In 1985, the company's revenues from China-related business reached more than US$17 million.[112] Along with direct sales, Wang set up a small service center in Beijing in early 1984; several months later it joined forces with the Hubei Radio Factory in Wuhan to establish a joint development center for cooperative activities in office automation, software development, and personnel training. Wang's underlying approach to China has been a strategy emphasizing sale and production of small machines, with the hope that these sales will lead to purchases of larger machines--around which all of the smaller machines can be connected and networked. Its major competitive advantage in China has been its Chinese character operating system, known as the VS (ideographic VS) system.

In 1980, Wang began negotiating with China's MEI's about the possibility of establishing a joint venture in the PRC. Three proposals emerged out of these discussions: 1)a jv with the Shanghai Computer Corporation in Shanghai; 2)a jv with the Xiamen

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[112] "Wang Starts Computer Sales Drive," China Daily, February 21, 1986.

Development Corporation in Fujian; and 3)a jv with the Beijing 738 Wire Communication Factory in Beijing. Initially, the aim was to introduce a CKD operation for its VS system at the Beijing 738 facility, a CKD operation for the Wang Office Assistant in Shanghai, and a CKD operation for the IPC (ideographic professional computer) system in Xiamen. Wang was to provide the machinery and related equipment as well as cash in setting up the production lines, while the Chinese would provide the manpower, some capital investment, the buildings, and other infrastructural support.

In each of the three proposed cases, Wang's major aim was to replicate its existing facilities in the US or elsewhere. Wang's orientation in setting up a joint venture(s) in China was to stress consistency with its proven operations. For example, Wang will not bring second-hand equipment into China; nor did it anticipate introducing any drastic changes in the mode of operation. Its hope was to utilize capabilities and knowledge at its production sites in Ireland, Scotland, Puerto Rico, Australia, Mexico, and Taiwan to assist with the start-up of its China ventures. Wang expressed its willingness to provide four key forms of technology transfer: manufacturing know-how, engineering and managerial know-how, software diagnostics, and after-sales service and maintenance techniques. Moreover, Wang stressed to PRC officials that the equipment intended for use in China was equal to that being used in the Wang facilities in Taiwan. This fact precluded the emergence of a major "technology transfer issue" in the negotiations--though the issue of the value of the technology did present a stumbling block at various points in the discussions.

A number of other issues also emerged during the course of negotiations between the two sides. First, the quantity and cost of training was a major concern of the Chinese. Wang made a special effort to define the number of people that would receive training, the tasks and areas of training, and the costs. In keeping with its policy of consistency, it offered China no more and no fewer training slots. China wanted as much training as possible.

Second, the question of foreign exchange remittance remained unsettled. It was agreed that after the 3rd year, each venture would have an export requirement of up to 25% of the output. China's aim is to have foreign firms hold large quantities of foreign exchange as an incentive for them to do more local sourcing and train local firms to be effective suppliers. (In general, PRC officials frequently apply unbearable pressure on foreign firms to source locally.) And, while Wang prefers local sourcing and local employees, it is also concerned with four key considerations: 1)quality to meet worldwide standards, especially since the products would be using the Wang trademark; 2)overall cost competitiveness; 3)ability to meet delivery schedules; and 4)ability to meet volume requirements.

Overall, Wang's main concerns with engaging in manufacturing operations in China revolved around China's lack of familiarity with large-scale mass production operations. Concerns existed about whether operations would ever get large enough to generate sufficient economies of scale to be profitable. Second, it was felt that local parochialism combined with bureaucratic infighting might continue to preclude the emergence of broad perspectives on marketing approaches. And, third, Wang officials feared that China's current manufacturing techniques and philosophies might interfere with meeting quality requirements. Moreover, while the potential return on Wang's equity investment in China was of direct concern, the real pressing issue was and continues to be the cost of doing business in China until the venture matures. Under these circumstances, Wang's initial strategy has been to keep its ventures small while minimizing unnecessary exposure, and using as a few expatriates as possible to prevent a drain on the joint venture's resources.

Since initial discussions began, the three proposed projects have been restructured due to a variety of factors on both sides. Wang's intention, with Chinese government support, is to initiate its first joint venture in Shanghai. Instead of producing the Office Assistant at this site, however, the IPC (ideographic PC) will now be produced. The change was necessitated y the fact that the performance of the IPC has gone up and the p ce has gone down, thus reducing the attraction of the earlier p duct. The venture, which is due to come on line in early summ 1986, will require extensive renovation of an existing facility n Shanghai. The decision to proceed first with the Shanghai ven re in China was not without its problems as the MEI felt somewh t concerned about its ability to control events in that munic ality. The bureaucratic rivalry between MEI and Shanghai was n something that could be easily dissipated. Nonetheless, in th interest of time and after taking existing technical capabi ities into consideration, MEI acquiesced.

H. National Security and China's Computer Developmen

As noted, one of the principle driving forces be nd computer development in China is the defense establishment, ich through the Science and Technology Department of the Nat nal Defense Science, Technology and Industries Commission, provi s financial and organizational support for computer development facilities under the Ministry of Electronics Industry (East Ch a and North China Computer Research Institutes), the Chines Academy of Sciences (Institute of Computing Technology), the inistry of Space Industry, and various universities.[113] In gen al, many of these facilities are not wholly dedicated to the military, but perform tasks for both civilian and military organizations.[114] The PRC missile program, nuclear weapons program, and its now emerging commercial space program are major sources of demand in terms of enhanced computer capabilities.

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[113] The personnel from these various organi ations have together formed a critical mass of key individuals. ee "Computer Scientists Aid Nuclear and Space Programs," FBIS-PRC, September 3,

It appears likely that the general upgrading of the research and production infrastructure for microelectronics will help contribute to both military and civilian computer developments. This is especially true in view of the recent admonition encouraging closer interaction between the military and civilian sectors.[115] Moreover, Zhang Aiping, Minister of Defense and former director of the NDSTIC, has on several occasions stressed the need for greater attention to electronics and computer development.[116] As such, representatives from the NDSTIC sit on the State Council's special leading group for electronics and

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1982, p.K20.

[114] A good example involves the number of civilian entities involved in the May 1980 launch of China's ICBM. See Gu Zengpei, "Talking About Achievements and Problems in Our Nation's Electronics Technology Based•on the Launching of the Cargo Rocket Into the Pacific," Dianzi Kexue Jishu, #120, November 1981, pp.43-48. For a discussion of these issues in the context of the Nanjing Radio Factory see also Dong Yu and Chen Jinyu, "Integration of Military and Civilian Production," Jingji Guanli, December 5, 1983, pp.31-33.

[115] See "Transfer of Military Technology to Civilian Use Is a Major Component of China's Technical Markets," Kexuexue Yu Kexue Jishu Guanli, #4, April 12, 1985, pp.6-7.

[116] "Zhang Aiping Urges Electronics Industry Growth," Xinhua, January 31, 1985 translated in FBIS-PRC, February 1, 1985, p.K13.

computer development, further supporting the high level of attention being given to the computer industry by China's defense leadership.

Two good examples of military-civilian interaction involve the development of the 757 10 mips mainframe computer by the Institute of Computer Technology under the Chinese Academy of Sciences and the Galaxy, a 100 mips computer developed by the National Defense Science and Technology University in Changsha. Both projects appears to be especially significant because they reflect a growing Chinese interest in supercomputers.[117] In a recent article by Qian Xuesen, the Cal Tech trained scientist most often associated with China's missile program, the functional role and evolution of supercomputers in the US and Japan are discussed, highlighting the importance for China of maintaining a presence in this area of important technological change.[118] In particular, Qian talks about the growing role of intelligent machines for solving not only mathematical problems, but in transforming the nature of work and how man and machines relate to one another.[119] He closes his article, however, with an admonition that supercomputer technology is treated like the technology for producting atomic weapons, etc. in the West, and therefore China must establish its own independent efforts to realize technological advances in this area.[120] The two projects discussed below seem to reflect this latter perspective.

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[117] While there are both potential military and civilian applications for supercomputers, the national security implications seem to be the most critical from the perspective of technology transfer. According to a Newsweek report, the importance of supercomputers lies in the fact that "these technologies will make possible a new breed of weapons and military hardware. Smart weapons--drone aircraft, unmanned submarines, and land vehicles--that combine artifical intelligence and high powered computing can be sent off to do jobs that now involve human risk." See William Marbach, et.al., "The Race to Build a Supercomputer," Newsweek, July 4, 1983. These machines are also useful in the design of very large-scale integrated circuits, such as advanced memory chips. See Businessweek, November 28, 1983, p.109. While China currently lacks the capabilities to make a significant push in these areas, development of such machines--supported by direct and indirect acquisition of foreign technology--could allow the Chinese to make much more rapid progress than might otherwise have been the case, particularly if such development is designated a high priority by the central leadership..

The 757 project, which originated in the mid-1970s, was ostensibly begun at the bequest of the Ministry of Nuclear Industry, while it was still known as the 2nd Ministry of Machine-Building. The project was designed to emphasize China's technological self-reliance; the electronic components and semiconductors needed for the computer were to come from domestic sources. The task of overall coordination was given to the CAS; along with providing technical support, the Institute of Computer Technology had to interface with the Institute of Metallurgy (CAS, Shanghai branch), the Beijing Dongguang Factory (#878), the Ministry of Electronics Industry, the Ministry of Chemicals Industry, the CAS #109 Factory, the Institute of Semiconductors (CAS), and the National Defense Science and Technology Commission--which provided overall funding. One machine was produced by the early 1980s; it is now being "upgraded" to the 30 mips level with the magnetic core memory being replaced by integrated circuits and the major components being imported from abroad instead of purchased from domestic sources.

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[118] Qian Xuesen, "On the Question of the Fifth Generation Computer," Ziran Zazhi (Journal of Nature), Volume 8, Number 1, January 1985, pp.3-9.

[119] Among the problems cited by Qian for application of supercomputers are non-linear partial differential equations, non-linear finite element analysis, and multi-order perturbation methods. Some of the applications of supercomputers noted by Qian include aerodynamics, the diffusion of gases, nuclear explosion technology, chemical molecule design, and quantum color dynamics.

[120] One of the other interesting aspects of the Qian article is his discussion of the debates over design in China during the development of the Galaxy computer. Implicitly, Qian suggests that Chinese computer scientists had not adjusted to the changing economic structure of computer technologies, whereby components were decreasing in cost and therefore did not have to be used as sparingly as they may have been in the past.

A similar example is found in the case of the Galaxy computer, which is said to be a Chinese version of the powerful Cray 1.[121] The Galaxy is projected to have a data processing capacity that can handle 100 million operations per second.[122] It is primarily being used for weapons-related calculations and petroleum exploration and weather forecasting.[123] The development of China's first "supercomputer" began in May 1978 and was accomplished by sending out "an investigation and Research Group many times to all parts of the country in order to gather extensive information and materials from both China and abroad."[124] Moreover, "some 20 groups, including Hunan University, Hunan Teacher's College, Fudan University, Wuhan University, the Ministry of Space Industry, and the Information Institute of the NDSTIC, detailed essential technical personnel" to work on the project, reflecting the proven ability of the NDSTIC to bring together critical resources to accomplish a high priority national goal.[125]

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[121] "Galaxy Sparks Illuminate China," Renmin Ribao, January 5, 1984, p.3.

[122] "Chinese Supercomputer Unveiled," China Pictorial, March 1984, pp.1-2.

[123] In addition to the work associated with the Galaxy project in Changsha, the Chinese have also developed an advanced array processor (NCI-AP2701) that has a processing capability of "tens of millions" of instructions per second. It was developed by the North China Computer Research Institute of the Ministry of

Even though the Chinese have officially announced the manufacture of one Galaxy machine, based on discussions in China and the US there is evidence that China may have actually built two Galaxy-like computers. One of these machines may be in Beijing at the Ministry of Petroleum Industry and the other still in Changsha. In contrast to the 757 project, however, the Galaxy relied on imports for over 90% of its component and semiconductor

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Electronics Industry. The new machine has projected applications in mineral prospecting, medicine, power management, and national defense.

[124] A good reflection of China's level of understanding vis-a-vis supercomputer technology is reflected in a survey of supercomputer architecture in the journal Dianzi Xuebao, Volume 11, #3, May 1983, pp.91-98 translated in JPRS-CST-85-006, March 6, 1985, pp.43-58. The Chinese are also extremely interested in the so-called "fifth generation" computer and have already begun some preliminary research in this area. China Daily, June 5, 1985.

[125] China Daily, December 22, 1983, p.1.

needs.[126] Upon its completion in May 1983, the State Council organized 95 computer experts and technicians from 29 different organizations to assess and evaluate the final product.[127] More recently, a preprocessor microcomputer for the Galaxy was developed by the NDSTU and put into production at the Tianjin #2 Radio Plant.[128] The preprocessor will help the Galaxy reduce operational costs and more efficiently handle large-scale projects.

In most cases (though not necessarily in all cases) internal technology sharing must be assumed in considering the sale of advanced computers to the PRC.[129] The only factor working against such sharing is the bureaucratic rivalry among Chinese organizations, though this appears to be much less of a serious problem when the defense sector is involved. As far as China's willingness to abide by existing US guidelines is concerned, the evidence is much less clear. In some cases, China continues to use Hong Kong as a site for procuring sensitive technologies as well as using HK-based firms as sites for training PRC nationals in technical areas presently prohibited for sale to China under US export controls.[130]

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[126] Personal communication, Beijing, January 1986.

[127] "Galaxy Super-Computer," Beijing Review, January 2, 1984, p.8.

[128] "Defense University Develops Super-Microcomputer," Xinhua, December 29, 1985 translated in FBIS-PRC, December 30, 1985, p.K18.

[129] A variety of physical devices as well as devices internal to the computer and its software can be used to prevent unauthorized access. In the case of the latter, attempts at access by unauthorized persons can be detected.

With respect to diversion of US technology, the only thing that can be said up to this point is that Chinese officials have been reluctant to go on public record to commit to a policy of non-diversion to third countries because it violates their sovereignty. Recent changes in the COCOM and export control guidelines, however, necessitate the issuance of an "end-user" certificate by MOFERT certifying that "all items... exported to the PRC are for use in the PRC and will not be reexported to a third country."[131] The dilemma faced by the US in this context, particularly with respect to the sale of larger machines, is no different than that associated with the Sino-American nuclear power agreement; either we feel confident about China's willingness to be a responsible international actor or we do not.

Aside from supercomputers, enhanced computer capabilities, including acquisition of foreign microprocessor technology, also have actual and potential application in China's strategic programs. The accuracy of China's intermediate and intercontinental missiles, for example, could be upgraded by relatively minor improvements in computerized guidance system operations.[132] These computer-related improvements would allow for better prelaunch calibration of the gyroscopes and accelerometers as well as better in-flight performance.[133] Computers also have begun to make their presence felt within the conventional warfare and training elements of the PRC military.[134] The military side of the Jiangxi Nautical Instrument Factory has introduced a minicomputer to assist with militia and reserve troop statistical work.[135] Additionally, the academies of the People's Liberation Army have begun to introduce all sorts of electronic computers for training and battlefield simulations.[136] For example, CEIEC has been promoting the sale of the SHMX II-II anti-tank missile simulator abroad after it has been successfully introduced with PLA training programs.[137] Moreover, China's entire orientation to military logistics on and off the battlefield has been influenced by the availability and potential application of computers.[138]

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[130] "Information Systems: Hong Kong Winning Name of China's Smugglers' Cove," MIS Week, May 22, 1985, p.20.

[131] The "inclusion" of MOFERT in the proceessing of licenses places part of the bureaucratic burden on the PRC side by giving the Chinese side a vested interest in reviewing and issuing certification requests as rapidly as possible. From a political perspective, it also places the major responsibility for non-diversion in Beijing's hands.

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[132] China's recent advances in its space program reflect a host of computer-related advances both in terms of performance and general application.

[133] See John Tirman, ed., The Militarization of High Technology (Cambridge: Ballinger Publishers, 1984), pp.45-61.

[134] From an overall perspective, computers have the potential of significantly decreasing the cost of weapons systems and related military equipment while signficantly improving performance levels and characteristics.

[135] Zhongguo Minbing, February 9, 1985, pp.42-43 translated in JPRS-CPS-85-065, July 1, 1985, p.113.

[136] According to one US weapons expert, simulations are revolutionizing the training of pilots and other equipment operators. Computer simulators recreate, at reasonable cost, the fast-paced combat conditions that are often too dangerous and expensive to duplicate in reality. See William Perry and Cynthia Roberts, "Winning Through Sophistication," Technology Review, July 1982.

I. The Socio-Political Impact of Computers

As the technological changes associated with computers move ahead, the contribution of these changes to social stability tends to grow weaker and weaker.[139] Viewed from such a perspective, the potential impact of computers on Chinese societal development could be significant. In many cases, decisions about export control cases rarely reflect the tradeoffs between the benefits that increased computerization might provide, e.g. stimulating greater political openness, versus the national security risks involved. Propelled by catchy phrases such as Toffler's "third wave," the Chinese have gone for computers in a big way, perhaps much faster than they even realize. In many cases, it seems clear that Chinese leaders have not considered the full range of socio-political impacts that persons such as Daniel Bell, Herbert Simon, and Sheryl Turkle have spoken about in their analysis of computers in the West. Major changes are on the horizon for China in the workplace, in educational institutions, and in their political system if present trends towards the use of computers continue.[140]

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[137] Xiandai Junshi, #103, June 1985, p.7.

[138] Cheng Fang-kuang, "Reform of Logistics Work in the Chinese Communist Army," Chung-kung Yen-chiu, January 15, 1986, pp.103-109 translated in JPRS-CPS-86-027, March 26, 1986, pp.95-107.

[139] Wilson Dizard, The Coming Information Age, 2nd edition (New York: Longman, Inc, 1985).

To some extent, the problem posed by the proliferation of computers in China represents many of the other problems associated with technological change in the PRC: Chinese leaders believe that they can capture the advantages of advanced technology while minimizing socio-political and cultural change. History has shown that this is a difficult, if not impossible challenge. Many questions remain about what a "Chinese-style information society" will look like.[141] Moreover, recent discussions in China about the creation of a national computerized system for personal identification to replace the presently used system of hand-written ID cards raises potentially serious human rights issues for the US--particularly since the Chinese are looking to US firms to source the equipment and software to establish such a capability.

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[140] One issue that the Chinese have yet to encounter on a large scale concerns the problem of transborder data flows. This issue, which strikes at the heart of questions regarding national sovereignty and control, seems likely to emerge in China as more and more multinational firms arrive in the PRC with computer systems that wish to communicate with and transfer data to the computer systems of their parent in the US or other locations.

[141] Based on a number of articles in the Chinese press, there is a growing concern about computer security. Following the lead of the US Department of Defense decision in 1981 to set up a special computer security center, the Chinese have begun to introduce various forms of security devices, including passwords, access control matrices, encryption devices of a rather sophisticated nature, e.g. permutation schemes to encode data.

J. Projections of China's Computer Future

Technology transfer has played an important role in China's computer development, though mainly through indirect rather than direct means. Three types of technology transfer have occurred: a)import of computers as equipment for actual applications; b)use of foreign computers as models for reverse-engineering and imitation; and c)use of Western components for manufacture of domestic and foreign designed machines. In most cases, it is clear that the Chinese have benefitted from their expanded access since the late 1970s to foreign equipment and technical literature--though the full extent of the impact remains uneven and uncertain at this point. Largely through the process of reverse engineering, however, the Chinese have used knowledge of foreign designs and operating principles to advance their current mainframe and micro computer development programs. Progress has been appreciable with respect to the latter category, with 8-bit machines and more recently 16-bit computers most clearly reflecting the results of foreign "borrowing." And, as the case of the Great Wall microcomputer indicates, when foreign design concepts have been mastered, "replication" has become much less difficult since it has become easier (due to export control relaxation) for China to secure many of the necessary foreign semiconductor and integrated circuit components to build such machines.

At the same time, however, because of the limits inherent in the role of reverse engineering as an effective vehicle for technology transfer, the contribution of foreign imports to overall domestic technological advance has been less than anticipated. These "process" problems have been compounded by China's own shortcomings with respect to personnel and components production and quality as well as overall manufacturing techniques. Moreover, as the requirements for so-called "customized" components have grown, the Chinese have found themselves overly dependent on more standardized imported components that are unable to meet more specific design needs or on a domestic industry that all too often cannot meet component supply requirements in terms of numbers and reliability.

Nonetheless, by the end of the decade, even though the Chinese will not significantly close the gap with the West and Japan in overall computer technology, China will move ahead in a number of facets of its computer industry. And, while recent economic reforms may be one driving force behind this progress, the major impetus will still lie within government hands. Through its current efforts to build a broad-based research and production infrastructure for computer development, both central and local government organizations will, in effect, be absorbing the start-up costs for establishment of a viable computer industry. High-level bodies such as the Leading Group for Electronics under the

State Council promise to ensure that sufficient resources are made available for these purposes. Additional pressures from the Chinese military, which are likely to increase over time as they seek out a larger share of existing resources, will also support continued emphasis on computer development.[142] Thus, the essence of the strategy for computer development will be similar to that of electronics, that is, a "two pronged strategy," whereby the ability of the central government to orchestrate critical projects through its tasking authority will be combined with use of market forces to stimulate innovation in terms of both design and application.

China's banking system and financial institutions appear to be one of the largest potential clients for both domestic and imported foreign computers.[143] The five key banks in China, the People's Bank, the Bank of China, the Industrial and Commercial Bank of China, the Agricultural Bank of China, and the People's Construction Bank of China all plan to greatly expand the use of computers to conduct their business and link their offices throughout the country. Along with banking, other major uses will be in the tourist/travel industry and the education system as well as in general overall industrial management and national defense.

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[142] The demand for computers is also likely to come from the need for better radar and navigation systems, training simulation equipment, and command and control capabilities as well as from strategic weapons programs.

[143] "Banking on Computers," China Daily, October 2, 1984, p.2.

Based on the successful implementation of the current strategy for computer development, the following "pockets of excellence" are likely to emerge:

a)Software development. Software development will continue to be a high Chinese priority in terms of investment and R&D activities. China does not have the burden of a large inventory of ill-structured programmes to maintain. Given the potential to build a "clean" software industry, combined with the low cost of Chinese technical labor, it is likely that China will close the prevailing software gap at a faster pace than hardware. This may result in a significant Chinese presence in global software markets, particularly if it can build "alliances" with Western computer firms that have access to the latest hardware developments and also have established market access. Included in this category is Chinese character-based software covering the full spectrum of industrial, financial, and scientific programs.

b)Microcomputer development. In view of the progress that has been made in the design of machines such as the Great Wall 0520, which is said to be a clone of the IBM PC/XT, China will gradually take the lead in producing what may turn out to be one of the "microcomputers of the Third World."[144] In view of China's cost structure as well as its current ability to imitate and reverse engineer Western designs, a Chinese-built microcomputer could be competitive with prevailing Western models, especially if the Chinese can parallel their progress in computer development with similar improvements in microelectronics technologies.[145] Even if this does not materialize, it is possible to visualize a scenario whereby the Chinese become major OEM (original equipment manufacturers) producers for some of the larger computer manufacturers. Over the longer term, PRC efforts could be boosted by various forms of technological cooperation from Singapore, Hong Kong and even Taiwan--all of which have a growing familiarity with Western levels of sophistication.

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[144] To test the acceptability of the Great Wall computer, it was recently shown at an exhibition in the US in November 1985.

c)Supercomputers. Even though the Chinese will remain generally 5-7 years behind in their ability to mass produce both micro and minicomputers, they will continue to be adept at channelling their limited resources and overcoming existing organizational barriers to attain state-of-the-art technology levels in a number of key defense-related areas, foremost among them being large computers. Chinese computer specialists have paid careful attention to supercomputer development in the West and Japan (as well as such projects as VHSIC--the effort to create very high speed integrated circuits), and have a good grasp of developments towards production of the so-called "fifth generation" computer. The Galaxy program manifests a determination to close the prevailing gap with the West, a determination that is apparently supported by the availability of all sorts of financial, technical, and personnel resources. And, while some questions remain about the performance of the Galaxy as compared with the Cray, the fact remains that the Chinese were apparently able to master not only the electronics aspects, but more critically, the cooling technologies that lie at the heart of the Cray system. If such is the case, this does suggest a potential area where China could make substantial progress over the next five years.

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[145] In 1983, China exported its first set of computers, the BCM-III, which is an 8-bit, single board computer. According to reports, 1000 units were sold to West Germany--though interviews in that country did not indicate the existence of this product in the retail marketplace. Discussions in Beijing in January 1986, however, did reveal that the BCM-III happens to be one of the computer series that cannot find an adequate market in China, let alone be sold in large numbers abroad.

Progress in each of these areas holds important implications for the US. From an economic perspective, improved application of computers, be they foreign or domestically produced, will assist the Chinese in all facets of their modernization program. Given the US policy of support for the four modernizations program, it is reasonable to conclude that the US should promote and facilitate the expanded use of computers in China. Cooperation programs and educational exchanges associated with information systems and technologies should be given adequate political and financial support. Without such support from the US Government (and US allies), many of the improvements in managerial efficiency, productivity, and coordination that are needed to modernize the PRC economy will be delayed or inhibited from occurring. As such, export controls that unneccesarily restrict the sale of equipment and related items to China in support of economic modernization should be adjusted or removed.

From a commercial perspective, Chinese manufacturers, if joined together with US firms through joint ventures, etc., could serve as important production complements to America's computer industry in much the same way that Taiwan and South Korea do today. At the same time, however, it is also clear that China does not want to be a mere appendage to the US economy, and will increasingly encourage "domestication" of its computer industry, gradually decreasing the amount of direct control foreign firms have over this high priority industry--but not decreasing the push for expanded levels of technology transfer. This suggests that access to the Chinese market may become increasingly scarce as Chinese capabilities improve. In effect, the transfer of technology to the PRC may provide for some short-term rewards, but as presently structured, the currently emerging relationships between US and PRC firms may not provide the basis for long-term commercial cooperation.

On the military side, there is little doubt that the acquisition of foreign computers and related technologies will assist the PRC in all facets of its military modernization program. The real question is how far and how fast will China's military progress? Of greatest concern should be the potential contribution of China's computer revolution to strategic weapons programs. It remains to be seen whether the risks of directly or indirectly supporting such programs can be successfully ascertained at this point in time based on our current information base and knowledge of Chinese intentions. For the present, this level of uncertainty suggests that caution should be our guiding principle in managing advanced computer sales to the PRC in the short-term. Moreover, the likelihood of internal diversion from approved civilian users to unauthorized military end-users remains very high--and so do the potential security risks if such diversions do take place. Before further significant relaxation in present controls does occur, it would do the US well to gain more insight into the future of the post-Deng succession, the precise meaning to the US of China's "independent" foreign policy posture, and the evolving role of the PRC military within the realm of domestic politics and foreign policy decision-making.

Chart 1

Organization of China's Computer Industry

(within the MEI)

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                          Ministry of Electronics Industry
                                         ¶
                                         ¶
-----------------------------------------------------------------------
¶                       ¶                ¶              ¶             ¶
Broadcasting         Radar          Computers          ¶          Components
(TV & Radio)                       (former SACI)        ¶
                                         ¶            CEIEC
              Administrative Offices-----¶
                                         ¶
                                         ¶
    ----------------------------------------------------------------------
    ¶        ¶           ¶       ¶       ¶       ¶        ¶      ¶       ¶
Great     Ai Hua    Nanjing  Nanfang   Huabei  Huanan    Xinan San Yi  China
Wall    Electronic   Zijin   Informat Terminal Computer  Comp   Comp  Magnetic
Inform    Wire      Computer Industry  Equip    Corp     Corp   Corp  Equip
Corp      Corp       Corp      Corp     Corp                           Corp

                                         ¶
                                         ¶
    ----------------------------------------------------------------------
    ¶           ¶                   ¶                 ¶                  ¶
Engineering   R&D               Service             Users             Software
Companies   Institutes (China Comp Tech Serv Corp)  Assoc   (China Comp Software C
    ¶           ¶                   ¶                 ¶                  ¶
----------      ¶   ----------------------------      ¶   -----------------------
¶         ¶     ¶   ¶        ¶       ¶        ¶       ¶  ¶       ¶       ¶      ¶
China   China   ¶  Liao-  Beijing Shanghai Tianjin    ¶ Liao- Beijing Shang-  Tian
Comp    Comp    ¶  ning                               ¶ ning            hai   jin
System  Mach    ¶        (Main Branches)              ¶
Engin   Room    ¶     (plus 41 local branches)        ¶
Corp    Engin   ¶                                     ¶
        Corp    ¶                 ----------------------------------------
                ¶                  ¶                  ¶                 ¶
                ¶                China         Microcomputer        Microcomputer
                ¶               Computer          User              Research &
                ¶             User Assoc          Assoc              Application
 -------------------------------------------------------               Assoc
 ¶            ¶                ¶            ¶          ¶
North       East           Taiyuan      Taiyuan  Beijing Polytechnic
China       China         Peripheral    Magnetic   University
Computer    Computer       Research     Materials       2nd
Res Inst    Res Inst       Institute    Res Inst   Branch Dept
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Chart 2

China's Electronics Industry

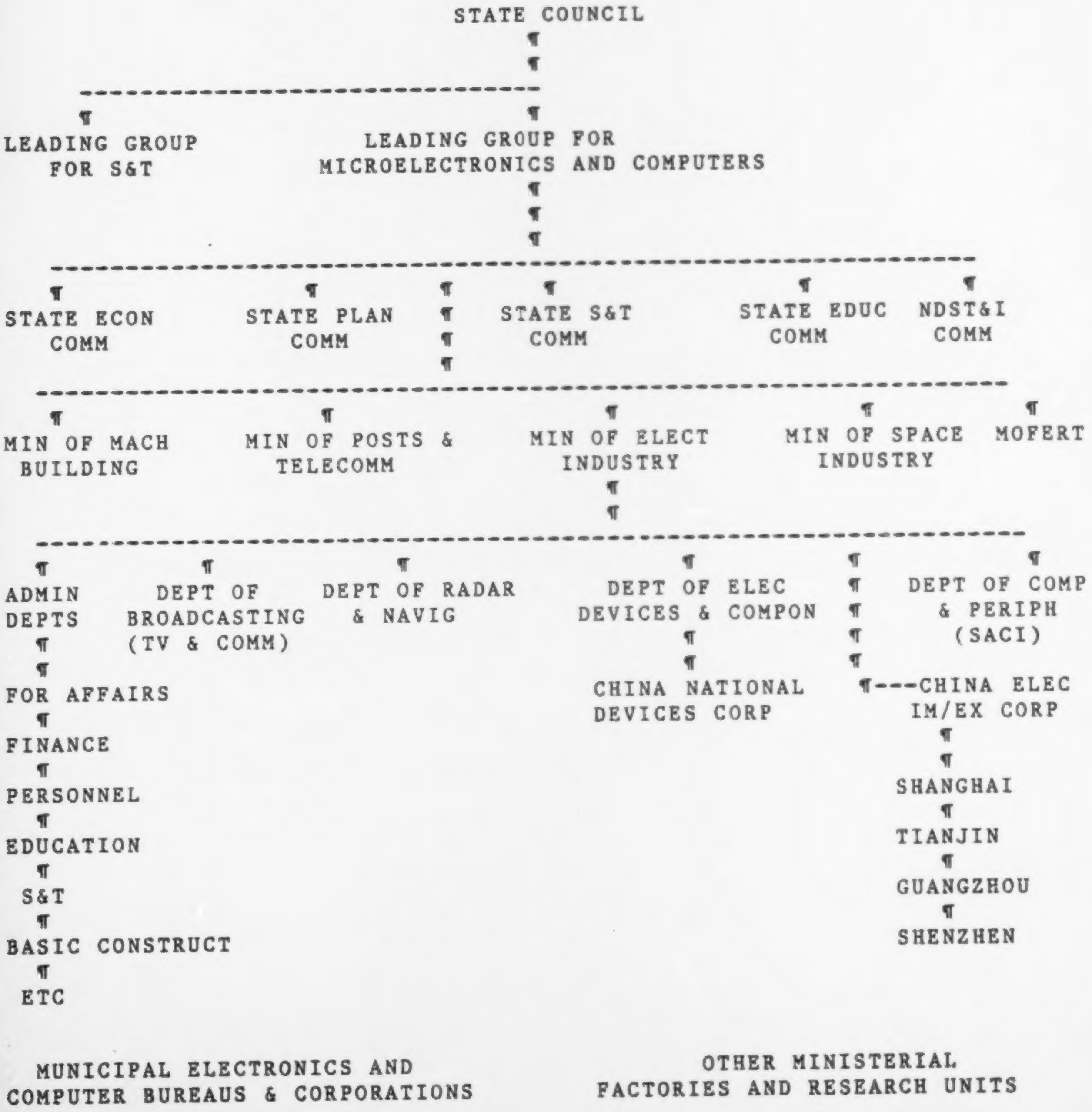
STATE COUNCIL
LEADING GROUP FOR S&T
LEADING GROUP FOR MICROELECTRONICS AND COMPUTERS
STATE ECON COMM
STATE PLAN COMM
STATE S&T COMM
STATE EDUC COMM
NDST&I COMM
MIN OF MACH BUILDING
MIN OF POSTS & TELECOMM
MIN OF ELECT INDUSTRY
MIN OF SPACE INDUSTRY
MOFERT
ADMIN DEPTS
FOR AFFAIRS
FINANCE
PERSONNEL
EDUCATION
S&T
BASIC CONSTRUCT
ETC
DEPT OF BROADCASTING (TV & COMM)
DEPT OF RADAR & NAVIG
DEPT OF ELEC DEVICES & COMPON
CHINA NATIONAL DEVICES CORP
DEPT OF COMP & PERIPH (SACI)
CHINA ELEC IM/EX CORP
SHANGHAI
TIANJIN
GUANGZHOU
SHENZHEN
MUNICIPAL ELECTRONICS AND COMPUTER BUREAUS & CORPORATIONS
OTHER MINISTERIAL FACTORIES AND RESEARCH UNITS

Chart 3

Major Achievements in China's Computer Industry, 1977-85

1977	Development of China's first microcomputer (DJS-050)
1979	Development of HDS-9 (5 MIPS) by CAS Institute of Computer Technology
1979	Development of DJS-052 microprocessor (8 bit, one chip)
1983	Development of China's first supercomputer ("Yinhe" ["Galaxy"],100 MIPS) by the S&T University for National Defense in Changsha
1983	Development of the 0520 microcomputer (IBM PC compatible) by the MEI Institute No.6 and production by Beijing Wire Communications Factory
1983	Development of the "757" 10 MIPS parallel computer by CAS Institute of Computer Technology
1983	Development of a 16 bit desk-top computer (77-II) by the Lishan Microcomputer Corporation
1984	Development of the 16 bit TQ-0671 microcomputer system by the Tianjin Computer Institute (CPU: MC 68000)
1985	Development of NCI-AP 2701 floating point array processor by MEI North China Institute of Computer Technology
1985	Development of NCI-2780 super-minicomputer (32 bit) by North China Institute of Computer Technology (Clone of DEC VAX 11/780?)
1985	Development of 8030 computer by East China Institute of Computer Technology (compatible with IBM 370/138)
1985	Development of YH-X1 super-minicomputer by the S&T University for National Defense in Changsha
1985	Development of YH-F1 emulator by the S&T University for National Defense in Changsha

Source: Assorted Chinese and English-language publications.

Chart 4

China's Leading Computer Facilities

Name	Location
A. Manufacturing	
Beijing Wire Communicaations Factory	Beijing
Beijing #3 Computer Factory	Beijing
Tianjin #2 Computer Factory	Tianjin
Nanjing Wire Communications Factory	Nanjing
Shanghai Computer Factory	Shanghai
Shanghai Broadcasting Equip Factory	Shanghai
Hangzhou Magnetic Equipment Factory	Hangzhou
Suzhou Computer Factory	Suzhou
Wuxi Computer Factory	Wuxi, Jiangsu
Lishan Microcomputer Factory	Xian
Shenzhen Aihua Electronics Company	Shenzhen SEZ
B. Research & Development	
Huabei Computer Research Institute	Beijing
Huadong Computer Research Institute	Shanghai
Institute of Computer Technology, CAS	Beijing
Chengdu Institute of Computer Applic	Chengdu, Sichuan
National Defense Univ for S&T	Changsha
Qinghia University	Beijing
Shanghai Jiaotong University	Shanghai
MEI Research Institute #6	Beijing(?)
MEI Research Institute #18	Changsha
MEI Research Institute #52	Taiyuan
MEI Research Institue #53	Liaoning

Source: The China Directory of Machinery and Electronics Enterprises (Beijing: Machine-Building Industry Publishing House, 1984) and China Scientific Research and Technology Services Handbook (Beijing: Guangming Daily Publishing House, 1984).

Table 1

Mini and MainFrame Computer Sales to China

(as of January 1985)

Manufacturer	# of Installation
Burroughs	38
Control Data	18
Data General	20
Digital Equipment(DEC)	350
Fujitsu	74
Hewlett-Packard	66
Hitachi	97
Honeywell	108
IBM	100
Nippon Electric(NEC)	20
Prime	19
Siemens	20
Sperry	8
Toshiba	10
Wang	220
USSR/East Europe	40
Others	31
Estimated Total	1,239

Source: International Data Corporation, Hong Kong, Sept 1985.

Table 2

US Computer & Related Equipment Sales to China
(in thousands of dollars)

Item	1981	1982	1983	1984	1985
Analog & Hybrid Computers	163	5041	1715	2082	6767
Digital Computers	5158	11337	11324	25265	80062
Digital Central Processing Units	5179	2169	10816	32494	35411
Random Access Aux Storage	1052	1049	1849	1519	7399
Serial Access Aux Storage	140	430	680	1995	5204
Terminals	699	1108	2241	2261	3900
Printers	645	626	1063	1814	3454
Communication & Peripherals	268	1644	2301	8006	9175
Parts, etc.	3763	8376	11913	20476	31710
Microprocessor Integrated Circuits	104	25	4	50	47
Printed Circuit Boards	258	58	557	1407	2245
Cathode Ray Tubes	8	91	22	179	417

Source: Office of Chinese Affairs, US Department of Commerce, 1986.

Table 3

Selected Chinese Microcomputers

Computer	Manufacturer	CPU
DJS-060 Series (8)	Shenyang-Liaohe Inst	MC6800
DJS-060 Series (8)	Sichuan Solid State Inst	MC6800
DJS-054 (8)	Shanghai Computer Factory	8080A
DJS-033 (8)	Nanjing Wireless Radio Fact	6502
DJS-044 (8)	Beijing Wireless Radio Fact	Z80A
BCM-III (8)	Beijing #5 Computer Factory	Z80
DJS-065A (8)	Tianjin #5 Wireless Factory	MC6800
DJS-028 (8)	Guangzhou Computer Plant	Z80
DJS-083A (8)	East China Normal Univ	Z80
Great Wall 0520 (16)	Beijing Telecomm Equip Fact	8088
Zijin-II (16)	Nanjing Zijin Computer Factory	Z80
GF-20 (16)	Beijing-Guangdong Computer Ctr	Z80A
TP-801 (16)	Beijing Polytechnic University	8086
TP-86A (16)	Beijing Polytechnic University	8086
77-II (16)	Lishan Microcomputer Factory	8086(?)
TQ-0671 (16)	Tianjin Computer Factory	MC6800

(8) = 8-bit microcomputer
(16)= 16-bit microcomputer

Source: *China Computerworld*, Beijing, 1984-85.

Table 4

Estimated Computer Production in China

Type	1981	1982	1983	1984	1985
Single-Board Microcomputer	1500	5700	10499	35000	50000*
Microcomputer	380	1487	5436	27340	60000*
Minicomputers & Mainframes	147	223	364	700	1200*
TOTAL OUTPUT VALUE (RMB MILLION)	402.5	487	794	1589	3655*

Source: *China Computerworld*, Assorted Issues, Beijing. *Almanac of China's Economy*, Beijing, 1981-1985.

Table 5

New US Computer Export Regulations
(as of December 1985)

1. Digital computers: a)operated by civilian end-users for civilian purposes; b)are exported as complete systems or are enhancements of previously exported systems; c)have been primarily designed for non-strategic uses; and d) do not fall outside the scope of the following limits:

   A.--Total processing data rate of 155 Mbit per second and total connected capacity of main storage of 72 Mbit; or
   --Total processing data rate of 100 Mbit per second and total connected capacity of main storage of 134.5 Mbit.

   B.--Input/Output control unit:

   --Total bit transfer rate of 101 Mbit per second
   --Maximum bitransfer rate of any drum or disk drive of 34 Mbit per second
   --Total connected "net capacity" of 74,000 Mbit.

   C.--Array Transform Processors:

   --Equivalent multiply rate of 800,000 operations per second
   --Fast Fourier Transform of 1024 complex points--40 ms.
   --Word Length--38 bit.

2. Microcomputers:

   A.--Total processing data rate of 15 Mbit per second

   B.--Virtual storage capability of 512 million bytes

Source: *Federal Register*, Volume 50, #249, December 27, 1985.

Table 6

Selected Examples of PRC Computer Imports & Forms of Cooperation with Foreign Corporations

Foreign Firm	PRC Organ	Nature of Project	Date
Control Data Corp (US)	Min of Petro Industry(?)	Sale of 2 Cyber 172	1976
Sperry Univac (US)	CNMIEC	Sale of 1100/11 & 1100/12 systems	1978
Hitachi (Japan)	CNMIEC	Sale of 3 mainframes & 2 M-160 mainframes*	1978
Hitachi (Japan)	People's Bank People's Insurance	Sale of 11 M-150 comp	1979
Burroughs (US)	Beijing Inst of For Trade	Sale of B3950 & B876 computers	1980
Fujitsu (Japan)	Tianjin Municipality	Establish large inform system	1980
IBM (US) (United Nations)	CNTIC	Sale of 16 series 4300 computers for census	1980
Sinclair (UK)	South China Comp Corp	Assembly of ZX-81 & Spectrum home computers	1983
Sperry (US)	China Computer Tech Services Corp	Technical services	1983
Sems (France)	Guangzhou Municipality	Manuf Solar 16 minicomp	1983
IBM (US)	Instrimpex	Sale of 11 4341 comps	1983
IBM China (US)	Min of Educ	Donate 100 5550 micros to MoEd	1984
Kanematsu-Gosho (Japan)	--	Marketing & service for IBM PCs: 5150/5160/5550	1984
General Robotics (US)	CEIEC	Assemble DEC-like minicomputers	1984
Honeywell (US)	Instrimpex	Service center	1984

Eastern Computer (US)	Henan Inter Econ-Tech Corp	Computer components & software	1984
Control Data Corp (US)	MEI/SACI	R&D and training in computer technology	1984
Hewlett-Packard (US)	CEIEC	JV for microcomputer assembly/manuf	1984
Burroughs (US)	Yunnan Elec EquipFactory	Distribute & assemble B20 & B25 microcomputers	1984
NEC (Japan)	North China Term Equipment Corp	Assembly of PC-9801F microcomputer	1984
Wang (US)	Xiamen Constr & Develop Corp	Assemble microcomputers & distrib Wang products	1984
Wang (US)	CEIEC (Shanghai)	Produce microcomputers	1984
Gould (US)	CNMEIEC/Tianjin Automation Factory	Assemble industrial programmable controllers	1984
Altos (US)	Shaoguan Radio Factory(Guangdong)	Sale of production line for 16-bit microcomputers	1984
Honeywell (US) (World Bank)	Ministry of Educ & CNTIC	Sale of 14 Systems (DPS 6 & DPS-8 plus software)	1984
Honeywell (US)	Great Wall Corp (MSI)	Sale of DPS-6 systems	1984
Sumitomo & NEC (Japan)	Min of Education	Sale of 305 8-bit PCs	1984
Fujitsu (Japan)	CNTIC & Meterological Ctr in Beijing & several universities	Sale of 24 FACOM series large computers (360R, 360S, & 340S)	1984
Hitachi (Japan)	CNTIC	Sale of 12 small & med comp for constr, civil engin	1984
Genisco (US)	Hunan Comp Factory	JV to produce comp graphics terminals	1984
Data General (US)	Tianjin Comp Corp	Sale of 32-bit MV line & 16-bit desktop comp	1984
Digicon Geophysical (US)	Min of Petro Ind	Sale of seismic comp equip & software	1984

Cullinet (US)	China Comp Tech Service Corp	Application & develop of software	1984
Intel (US)	China Aero Tech Im/Ex Corp	Assemble 4000 86/310 & 286/310 microcomputers	1984
Chiu Hwa Elec (HK) William Elec Comp	Dalian Municipality	Manuf microprocessors & training	1985
Ling Lang Micro & Comp Corp (UK)	Guangdong Province	Manuf componts & microcomputer systems	1985
Prime (US)	Min of Railways	Sale of mainframe plus Medusa software	1985
Sord Comp (Japan)	CAS	Sale of 30-40 PCs plus est of PC training ctr	1985
DEC (US)	Min of Water Conservancy & Power	Sale of 4 VAX 11/780 minicomputers	1985
Prime (US)	Beijing Inst of Technology	Sale of Prime 9750 comp	1985
CDC (US)	Min of Petroleum Industry	Sale of 5 Cyber 180 computers & CAD/CAM software	1985
Groupe Bull (France)	CNTIC	Sale of 5 mainframes, 60 minis & 320 terminals	1985
Toshiba (Japan)	Nanjing Info Equip Corporation	Assembly of dot matrix printers	1985
Charles River Data Systems (US)	Tianjin Computer Factory	Subassembly of 32-bit Universe 68 computer	1985
Corporate Data Sciences (US)	Guangzhou/ Hong Kong	Sale of 4000 IBM PC/XTs 10,000 desktop comp	1985
Hitachi (Japan)	People's Bank	Sale of 15 computer systems (US$25-30 M)	1985
Hitachi (Japan)	Min of Railways	Joint development of software & sale of 30,000 microcomputers	1985
Urchida Yoko (Japan)	CAS	Joint development of computer software	1985

Sperry (US)	China Comp Tech Service Corp & Wuxi Comp Factory	Introduced MAPPER IC software system	1985
GE CALMA (US)	CNTIC	CAE/CAD equipment, incl. 60 Apollo workstations	1986
Mancos Computer (UK)	Hong Kong e.g. Chongqing Univ------>	Sale of general comps VAX 11/750	1986

Case Study

SATELLITE TELECOMMUNICATIONS TECHNOLOGY TRANSFER TO CHINA

Prepared by: John McLucas
Norman Getsinger

for

China Business Development Group
Alexandria, Virginia
July, 1986

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INTRODUCTION - SUMMARY

Shortcomings in communications infrastructure have been threatening the success of China's all-out drive for economic modernization. Fortunately, China's emergence as a space power has provided China with an opportunity to develop space communications as an adjunct to its faltering terrestrial communications system. Seizing the opportunity, China has been establishing a serviceable domestic satellite communications system including the launching, February 1986, of an operational Chinese communications satellite. Space communications successes have assisted economic development, bolstered national pride, contributed to national defense, and provided highly-visible evidence of China's technological capability.

The fact that China's satellite communications system has been developed with very little direct foreign technological assistance is regarded in China as a victory for self-reliance. The hiatus in U.S. launch services has even provided an opportunity for China to enter the international market with its less complex launch capabilities. Despite their progress, the Chinese are quite ready to admit to their comparative technological backwardness; a condition which has been reaffirmed by delegations of U.S. space technicians visiting China. There are important areas in carrier rocket and satellite technology in which the Chinese need and want technology transfer to narrow the technological gap with the developed countries and to establish an efficient and effective satellite communications. Obtaining from abroad the developmental technologies China needs is, furthermore, a principal objective of the Chinese leadership's "open" policy of economic relations with the outside world, a policy which has led to strong and growing commercial ties with Japan and the West.

China's capability to receive and absorb technology is especially high in satellite communications which, as a result of Beijing's comparatively generous allocation of human and material resources, are at a relatively advanced technological level. Yet problems affecting technology transfer remain. There is no overall communications development plan. Program management is weak. Funding of the program is not consistent. There is bureaucratic infighting over appropriate technologies which causes delay in imports of needed technologies.

Transferred technologies, even when the transfer is controlled, carry with them the possibility of strengthening China's military capacity. Yet current Chinese leadership policies, which appear likely to continue for the forseeable future, emphasize economic development in a peaceful international environment. At the same time, China is drastically cutting its military forces, reducing military expenditures, and deemphasizing military modernization. Nonetheless, China's Pacific neighbors remain apprehensive about Western programs for the transfer to

China of "defensive" military technologies. The transfer of satellite technologies for the peaceful use of space would appear comparatively less threatening.

There is strong competition among space powers to supply China's satellite technology import requirements. The U.S., because of its longer experience and technical capability, is best qualified to be the supplier. Furthermore, a wide range of U.S. agency programs is available to support U.S. commercial activity, either directly or indirectly. Although a sale of satellites has not materialized, U.S. companies have sold ground equipment including electronics. Given China's off-stated preference for U.S. technologies, and its space communications priority, the outlook for sale of sophisticated U.S. technologies is promising. However, U.S. suppliers face the double difficulty of U.S. export licensing restrictions plus the Free World (COCOM) licensing review. Also, U.S. competitors sometimes appear to be less restrictive in licensing technology transfer, and can frequently offer lower prices and better credits. Be that as it may, the U.S. must deal with persistent Chinese perceptions of a U.S. reluctance to transfer technology.

Since the Nixon policy breakthrough in 1972, successive U.S. administrations have built a U.S. - China relationship based on the principle that a secure, independent, developing China is essential to the peace of the Pacific. Fundamental to maintenance of the relationship is a continuing economic exchange involving trade, investment and, of course, technology transfer. Yet the exchange requires caution on our part since the U.S. and Communist China have no guarantee of continuing common interests.

In considering policy options for technology transfer to China, the U.S. has three general options. The U.S. can: tighten up on restrictions; continue the present policy of guarded response to Chinese requests;. adopt a new positive program of technology transfer. If the third option is chosen, satellite telecommunications provide an ideal medium. A combination of U.S. Government and private sector activities which establish a U.S. China partnership in the development of space communications could provide political, economic and strategic benefits which appear to outweigh the risks. The Chinese have been seeking such a relationship and, if the U.S. does not respond, China may well turn to another country. The Soviets have made overtures.

A. TECHNICAL BACKGROUND

1. Chinese Satellites and Launch Capabilities

The Chinese like to say that they were the first country to put payloads into space, having invented rockets some 700 years ago. But Chinese science languished until recent years. China began development of modern space capabilities in 1958 with experiments to develop sounding rockets, first with single stage liquid fueled rockets. Later, two stage liquid and solid fueled sounding rockets were developed.

The Soviet launch of Sputnik in 1957, and space activities of several nations, made it apparent to China that a modern nation must develop the ability to operate in space. Based on their success in the sounding rocket programs, the Chinese began a space program in 1965, leading to a family of launches and a series of spacecraft which have been successfully orbited.[1] They have launched 18 spacecraft into orbit in the last 16 years, beginning with the SKW-1 satellite launched on April 24, 1970.

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[1] "The Launch Vehicles of the Peoples Republic of China," Eleventh Communication Satellite Systems Conference, Jing Zhaoqian, First Secretary of Embassy, Washington, DC.

a) SATELLITES

Chinese spacecraft satellites which have been discussed publicly fall into the following categories:

1. communications satellites
2. earth resources satellites
3. meteorological satellites
4. scientific satellites
5. navigation satellites

While this study is concerned with the first category, it is worthwhile to mention the other types as a means of giving credit to the breadth of Chinese space activities.

The first satellite SKW-1, was called in Chinese "Dong Fang Hong" ("The East is Red"). This was a small (173 kg) battery-powered broadcast satellite which was able to transmit for several weeks before its batteries ran down. The SKW-1 fell from orbit in 1983 having been launched in April, 1970.

The next satellite, SKW-2, only slightly larger (221 kg), carried a scientific payload and was able to operate using solar cells and batteries for about eight years. It fell from orbit in 1979, having been launched in March, 1971.

There was a long (four year) gap before the next launch of a Chinese satellite. Some have interpreted the gap to represent a diversion of effort to the IRBM (Intermediate Range Ballistic Missile) program, which presumably enjoyed higher priority. Be that as it may, the next satellite launched July 27, 1975, was of an entirely different character. This satellite, called ERES (Earth Resource Exploration Satellite), weighed 1750 kg and fell from orbit in seven weeks.[2]

But it was first in a series of seven ERES satellites which have been successfully launched so far. The ERES satellite carries two cameras, one a CCD (charge coupled device) camera which transmits pictures to the ground with resolution of about 50 meter quality from an altitude of about 500 km. This camera operates in real time and can be used to direct a second camera of higher resolution (10-15 meters) which is returned to earth for processing and exploitation.[3]

---

[2] China's early earth observation satellites fell from orbit after short periods because, in low earth orbits, they encountered friction with associated heat and drag. Low altitudes permitted good resolution photographs with unsophisticated equipment. With better equipment aboard, higher altitutde satellites could give comparable results and the satellite would have longer life.

[3] Apparently, the complete satellite - not just the film capsule is returned from orbit. The Chinese statements are not too clear about whether it is perhaps only the camera and film - or even merely a film package which is returned. In any case, the return of film, etc. from space demands a sophisticated control technology. The reentry body is in orbit above the atmosphere moving at five miles per second. It must be reoriented so that, when its rocket thruster is fired, it will be slowed down by an amount which will cause it to reenter relatively close to the

The camera's wavelength characteristics are suitable for exploring earth resources. It is normally flown for one week before the film is returned to earth.[4]

While this satellite is listed as an earth resources satellite, it achieves good resolution (comparable to the French satellite SPOT) when flown at a nominal 500 km altitude. But since it also flies at about half that altitude, it is quite capable of producing higher quality images of 5 - 10 meter resolution which could have significant military value. As such, the system could give excellent results in revealing military order of battle information, tracking force deployment, aircraft stationed at airfields, ships in harbors, etc. These satellites are expected to be flown for several more years.

A fourth kind of satellite developed or being developed by the Chinese is a polar orbiting meteorological satellite. This satellite has been seen by a number of visiting Americans

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recovery forces on the ground. Before it falls into the atmosphere, it must be reoriented so that its heat shield will protect it from burning up. China claims to be the third country to master the technology. The U.S. mastered this technology and returned its first film capsule in 1960. The Chinese had 15 years of knowing in general how we did it, so perhaps it is not surprising that they mastered the technology by 1975.

[4] China's Developing Space Program, by Jing Zhaoqian and J. Lynwood May, Signal Magazine, Feb. 1986.

(including a study team member) as it nears completion.[5] It is quite comparable in appearance and planned operation to the RCA Block V weather satellites operated by NOAA & USAF.[6] It should be ready for launch in 2-3 years (1988).

A fifth kind of satellite seen in some Chinese literature is a navigation satellite. There have been no launches of Chinese navigation satellites so far.[7] A complete list of Chinese satellites launched to date together with orbital parameters and other data is found in Table I.[8]

The two geosynchronous satellites (experimental communications satellites), which have been launched in the last two years are discussed separately below.

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[5] Unpublished Trip Report, AIAA Executives Visit to Chinese Space Technology Facilities, May 5-15, 1985. John McLucas and James Harford.

[6] "Chinese Seek Assistance in Weather Satellite Program," Aviation Week & Space Technology series on Chinese Space Technology, Craig Covault, August 5, 1985.

[7] Confirmed in oral conversation with Jing Zhaoqian at Chinese Embassy.

[8] China Inaugurates a Satellite Television Network. Harold Jacobson United Sates Information Agency, April, 1986.

b) LAUNCHERS

China has developed in the last 20 years three types of rockets suitable for placing satellites in orbit. They are called Long March rockets. In Chinese, long march is "Chang Zheng," so the rockets are known as CZ-1, CZ-2, and CZ-3.[9]

CZ-1 is a 3-stage rocket using liquid propellant first and second stages and a solid rocket third stage. The CZ-1 was used to launch China's first two satellites in 1970 and 1971. It is capable of putting 300 kg into low earth orbit.[10] An improved version is said to be under development, which will be capable of putting 400 kg into low earth orbit. China next developed the CZ-2, a 2-stage liquid propellant rocket capable of launching 2000 kg into low earth orbit. The CZ-2 was used to launch the 1750 kg ERES satellites beginning in 1975. Compared to the CZ-1 with 82 tons lift-off weight, the CZ-2 lifts off at 191 tons (metric tons). This launcher made news recently when the Swedes agreed to launch their Mailstar satellite on it.

China now has a rocket, CZ-3, which uses the first two liquid propellant stages of CZ-2 and a cryogenic upper stage (liquid oxygen, liquid hydrogen stage). China is proud to be only the third entity to achieve a cryogenic stage (after USA and ESA). This launcher was used to launch the two communication satellites, STW-1 and STW-2 in 1984 and 1986. CZ-3 is comparable in lift-off weight to CZ-2 (actually 202 tons) and is capable of putting 1.4 tons into geosynchronous transfer orbit. (Variously reported as 1.3 or 1.4 tons.)

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[9] "The Launch Vehicles of the Peoples Republic of China," Eleventh Communications Satellite Systems Conference, AIAA.

[10] Ibid

Further data on China's rockets is shown in several figures (attached). Figure I shows the CZ-2C/OTM with three satellites on board. In 1981, this launch vehicle CZ-2C put in parking orbit a package consisting of three satellites and the OTM (Orbital Transfer Module). As shown in Figure II, the OTM then put the three satellites in separate orbits. Launch took place at the Jiuquan Space Center in Northern China.

Figure III shows the CZ-3 launch vehicle with a communications satellite on board. Launch took place from the new Xichang Space Center in central China. (For synchronous orbit, the further toward the equator the launch site, the larger the payload for a given rocket.) In April 1984 and February 1986, the CZ-3 launched eastward, using tracking stations in China plus three tracking stations on ships placed along the satellite trajectory. In both cases, the satellite was successfully placed in GTO (geosynchronous transfer orbit) and later boosted into geosynchronous orbit by firing an apogee motor on board the satellite. Figure III merely shows the dimensions of the payload which can be mounted on the launcher.

The Chinese have explained a few failures of their launch rockets. The loss of the CZ-2 in 1974 (its first flight), is attributed to loss of the attitude control signal. Since then, there have been eleven successes of CZ-2.[11,12] Also, the first attempt to launch into geosynchronous orbit failed when in January 1984, the cryogenic stage of the CZ-3 failed to ignite for its second burn. After the trouble was diagnosed as a problem in the fuel pump, corrective action was taken, the engine retested, and two successful launches were achieved.

The record of Chinese launch successes, their desire to be recognized as a space power, their need to generate hard currency and recent U.S. launch failures, all have combined to produce the Chinese launch marketing campaign. Announced Chinese prices have varied over a fairly large range during the last several months beginning with numbers of 1/4 to 1/2 of going rates. More recently the Chinese seem to have pegged their prices at about 85% of going rates. This seems more reasonable if one accepts the idea that pricing too low brings into question the value of what

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[11] "The Launch Vehicles of the Peoples Republic of China," Eleventh Communication Satellite Systems Conference, AIAA.

[12] Craig Conault, Av. Week, July 8, 1985, "Austere Chinese Space Program Keyed Toward Future Buildup."

is being offered. In any case, if the offers to launch are made mainly to generate hard currency, it would seem logical to charge what the traffic will bear.

The Chinese marketing team to the U.S. in April of this year, visited a number of potential customers.[13,14] They also dropped in on NASA where they described their launchers, successes and failures, prices (85% of going rate), and insurance (10% of value of payload, second launch free). The marketing team was led by China Great Wall Industry Corporation, sole agency of the Ministry of Astronautics with the authority to quote price and delivery (1988 onward). Representatives of the Ministry of Astronautics and the Commission of Science, Technology and Industry for National Defense accompanied the delegation. Similar approaches have apparently been made in a number of other countries, several of which reportedly are interested -- and with Sweden having signed up and made a deposit to confirm the launch of Mailstar in 1988.[15]

A concern expressed by several potential users is that the Chinese may intend to use launches as a back door method of

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[13] Seth Paine in the magazine Science and Technology, April 14, 1986.

[14] Wash Post, April 5, 1986, section G, page 1.

[15] New York Times, March 30, 1986, UPI release

getting access to technology they could not otherwise get. The Chinese dealt with this fear adroitly. They pointed to their plan to have the satellite delivered via B-747 or C-5A to an airport with a 3500 meter runway some 50 km from the launch site at Xichang. From there, the satellite would be trucked over a good highway or go by rail to the guarded hangar for final processing and checkout before launch. Those who heard the presentation were favorably impressed.[16,17]

With the U.S. record of launch success (two successes out of the last five attempts), we are not in a good position to look too critically at the Chinese launch record. Just as NASA's refusal to continue the Atlas-Centaur production gave the market to Ariane, so the failures of STS, Titan and Delta may have put the Chinese in business.

c) FUTURE SPACE LAUNCHERS

The Chinese have announced that they have begun development of a greatly upgraded launch capability which would achieve GTO payloads up to 5000 kg (versus 1499 kg today). They plan to do this using existing building blocks plus a new upper stage. For example, a CZ-2-4L would use four strap-on liquid rocket boosters;

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[16] China Great Wall Industry Corporation brochure

[17] Report on a Chinese briefing of Comsat officials.

these boosters would use the same fuel and engines as the first stage. This combination could put 9000 kg in LEO (low earth orbit). similarly, the CZ3-4L with stretched tanks and four strap-on boosters could put 3000 kg in GTO (geosynchronous transfer orbit), double the CZ-3 present capability. The addition of the new cryogenic upper stage would take them to the 5000 kg capability which the U.S. is presently under contract to develop but is many years from having it as a shelf item.[18]

d) CHINESE GEOSYNCHRONOUS COMMUNICATIONS SATELLITES

The Chinese launched STW-1[19] on April 8, 1984 and soon parked the 925# (400 kg) satellite at 125° East longitude. According to their announcements, this is an experimental communication satellite which is used for a few hours per day for both telecommunications and TV broadcast. Although U.S. visitors found the lack of 24-hour service puzzling, this seems entirely explainable by the stated use of the satellite.[20]

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[18] Diagram of new launch capabilities, undated, unsigned, supplied by Chinese on recent visits.

[19] "STW" is Shiyan Tongxin Weixing = experimental communictions satellite

[20] Craig Covault, Aviation Week & Space Technology, Aug 12, 1985.

Not much is known of the technical details of the satellite. It measures about 1.8 meters by diameter and 2.3 meters high. Its solar cells cover essentially 90% of its cylindrical surface. Chinese solar cells are said to be about 11-12% efficient.[21] The number of traveling wave tubes inside is unknown but China is known to be able to build its own TWT's,[22] albeit of less than optimal efficiency. It is assumed that two transponders are on board. The horn antenna operating at C-band covers the whole earth with its footprint, thus leading to inefficiency, but the arrangement is not very different from that of the Intelsat-III satellites built by TRW in the last 60's. Intelsat III was a 335# satellite capable of handling 1500 telephone circuits.

Mr. Jing, S & T First Secretary at the Chinese Embassy, said that STW-2 could be compared to Intelsat III, although it (STW-2) was much heavier. If really comparable, then it should have four transponders. STW-2 has a narrower beam, not focused on China alone but 4-6 db improvement in power density over STW-1.[23] Jing said that Chinese TWT's are very expensive, heavy and not too efficient. They would not be competitive on the open market.

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[21] Craig Covault, Aviation Week, July 8, 1985, Austere Chinese Space Program Keyed Toward Future Buildup.

[22] Statement by Martin E. Packard, Varian Associates, Palo Alto, CA. Mr. Packard was a instrumental in developing Varian's technology transfers to China.

[23] Aviation Week series on Chinese space technology, July 22, 1985.

The first two Chinese communications satellites were launched about 20 years after the first Comsat launch. One way of measuring "lead" is the number of years between U.S. launches and comparable Chinese launches. Another is in the technical sophistication and/or efficiency of what is done. STW-1 has a horn which sprays energy over a cone in space which is larger than the earth. This allows for illuminating the earth even if the satellite does not point accurately at the earth. STW-2 has a larger antenna which generates a beam smaller than the earth but larger than China. This tends to show that the accuracy of pointing is being improved.

Similarly, the accuracy of Chinese station keeping is expected to improve. Western standards call for keeping a satellite within $\pm.1^\circ$ of its nominal fixed location. Mr. Jing at the Chinese Embassy said they have not tried to do this on STW-1 and STW-2. But the filings made by China for Chinasat-1, -2, and -3 with the International Frequency Registration Board for satellites to be launched in 1988 and 1989 call for that accuracy.[24] When the Early Bird satellite was launched in 1965, it was allowed to wander over about 20° to avoid deterioration of station-keeping thrusters. The Chinese apparently followed the same philosophy on STW-1. Jing said that the Chinese work in composite materials is important for reducing satellite weight and for low distortion under temperature cycling.

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[24] IFAB filings by China, dated 17 Dec 1985.

The critical elements in designing a satellite such as STW-1 or STW-2 include:

1. traveling wave tubes (TWT's)
2. batteries
3. solar cells
4. despin electronics and mechanical joints
5. thrusters for station keeping
6. earth sensors for pointing the antenna toward earth

Other less critical factors are designing for heat balance, discharging the fuel supply without displacing the center of gravity, and incorporating the right amount of redundancy to assure long satellite life in spite of component failures.

With respect to the above list, all items on the list have been in production for decades so it is not a question of some recent technology. All of these items are described in the literature of the professional/technical societies. Most of these items could be acquired by China through purchase from the West. However, China's goal -- restated many times -- is to develop an indigenous capability to produce all the components of a satellite communications system.[25] Since they have such systems in operation, they have established the fact that they can produce. They do not claim to be cost-competitive on any of these items but they have stated their intention to be so eventually. They are apparently 15-20 years behind us in satellite technology.

They recognize their limitations, and do not expect to come anywhere near to American capability in satellite communications in this century. In discussions with Mr. Jing, we were told repeatedly that China does not expect to be a competitor to the U.S. in this field. Rather, they see themselves as partners with us, concentrating or supplying the low-tech equipment and launches.

Areas where the U.S. has had trouble in satellites similar to STW-1 and -2 include the following:

1. station keeping thrusters of inadequate life
2. freezing of despin bearings -- lubrication problems
3. buildup of static electricity and damaging discharge
4. rapid decay of solar cell efficiency (radiation damage)
5. failure of earth pointing mechanism, causing spinup of satellite antenna

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[25] Visit by Chinese delegation to Comsat in 1978.

6. failure of the rocket inside the satellite (the so-called apogee motor)

All of these problems have led to degraded performance or actual loss of service at one time or another. All have been overcome as the state of the art has matured. Since China has only one such satellite with any significant life in orbit, we do not know yet whether they will experience difficulties of these types. It is reasonable to assume that Chinese technicians are familiar with all these problems and have taken steps to profit from our troubles and try to minimize the likelihood of similar problems.

While China is to be congratulated for having moved into the age of satellite communications, their demonstrated capability is still rudimentary in terms of supplying their own communications needs. To augment their meager existing capacity, China like many other third-world countries, has had the use of a leased Intelsat transponder which has been used for both telecommunications and TV broadcast. On May 9, 1986, Intelsat announced that China has purchased two transponders for domestic use, one to begin service on July 1, and the second on January 1, 1987.[26] China plans to use one for distribution of an educational service from Beijing to some 50 TV broadcast sites throughout the country. By year end, the number of TV stations equipped with 6-meter TV receive only antennas is expected to reach 200. The second transponder is to broadcast a news and cultural program. Because of mountainous terrain, it is said that about 1000 antennas will be needed to reach 64% of the land area.[27] Complete service would require some 30,000 antennas! Although China has announced that it is now self-sufficient in TVRO antennas, the statement apparently refers to their ability to make all the components of a TVRO earth station and not to the statement that they could soon make 30,000 of them.

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[26] Intelsat news release, 9 May 1986. Intelsat will supply China transponders using a so-called hemi-beam of eirp of 30 dbw power level. Intelsat has also sold transponders to Israel, Norway and Germany for a kind of direct broadcast service.

China has announced that a nation-wide communication system is necessary to "enhance political controls, national security and economic development."[28] Although China had earlier decided that its population should be reached by the more conventional means -- newspapers and radio, China has now decided that TV is the most effective method.[29] Accordingly, TV production has soared in the last few years, leading to a total population of about 50 million TV receivers. The attached table illustrates the buildup of production. Although the Chinese are said to prefer higher quality Japanese TV sets, it is not known how many have been imported.

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[27] China inaugurates a Satellite Television Network. Harold Jacobson, United States Information Agency, April, 1986.

[28] Quoted by a controlled source from a published Chinese document.

[29] Quoted by a controlled source from a published Chinese document.

(The Chinese have imported more than 250,000 computers, most of them PC's, so it is likely that at least as many TV's have found their way into the country.[30])

China's television system (See attachment "Table of TV Stations and Production") begins with studios in Beijing where China Central TV broadcasts to the local area and through an earth station to the satellite (either domestic lease Intelsat or eventually a Chinese satellite). There are large earth stations at the provincial level (29 provinces counting Shanghai and Beijing as provinces) to receive the central TV signal for rebroadcast. The antennas are 10-13 meter dishes. A third tier of county low- power TV stations are fed by smaller satellite dishes of about 6 meter diameter.[31] All these facilities will be called into play beginning on July 1 when the newly-purchased Intelsat transponders become available to China.

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[30] China study on Computers for OTA, Denis Simon, 1986.

[31] "China Inaugurates a Satellite Television Network", Harold Jacobson, United States Information Agency, April, 1986.

2. China's International Satellite Connections

In 1972, President Nixon visited China to begin the evolution of U.S.-China relations toward those of friendly non-allied nations. In order to remain in touch with the White House, Mr. Nixon called on Comsat to establish a 2-way communications link to Bejing. This was done by means of an 11-meter transportable antenna and associated equipment. A second antenna was soon added in Shanghai by RCA. As a gesture of good will, the second antenna remained in China after Mr. Nixon's departure, providing for continuous communications from China into the Intelsat network. The present whereabouts of the antenna left in China is not known, but China has bought from the West four 30 meter Standard A earth stations, two of which handle traffic through Intelsat's Pacific Ocean Region satellites, with the other two providing service through the Indian Ocean Region satellites. Two of these antennas are in Beijing, 2 in Shanghai. China's Intelsat service includes 86 circuits to the United States and a total of 525 circuits to all countries to which China has full time connections. China is also served by an undersea cable to Japan. There are a large number of circuits connecting China to Hong Kong. This is more like a domestic than an international link with about a 3000 call capacity cable connecting Hong Kong and southern China and an 1800 call capacity coax going overland to China. Cable and Wireless, the Hong Kong organization supplying interconnection to China, has gone out on bid for a fiber optic cable which would supply 12,000 additional circuits to China. This request for proposal is in line with the expected rapid buildup of traffic to China as Hong Kong prepares itself for passing under Chinese sovereignty.

While China began receiving Intelsat service in 1972, it did not become a member of Intelsat until 1978 (its interests in Intelsat being represented in the interim by Comsat). In 1982, China also joined Inmarsat, the organization supplying satellite communications service to ships at sea.

3. Elements of A Satellite Network

Although we have discussed much of China's involvement with satellites, we have not described a complete network. A communications satellite is frequently compared to a "bent pipe", the analogy being that communications signals flow like water from an earth station up to the satellite which turns the signals around and sends them back to the ground with as little loss or distortion as possible. To avoid interference between the signals going up and those going down, the satellite translates the signals coming in on one frequency band to a different band. Typically, signals are sent up in the 6 gigaherz frequency band. These frequencies are received, amplified and translated to the 4 gigaherz band for their return trip to earth. The combination of black boxes which perform all these functions is called a transponder, meaning it includes a receiver, a translator to change the signal from 6GHz to 4GHz, and a transmitter.

A satellite can be used to establish a link between two earth stations which may be close together on the earth or thousands of miles apart. The two earth stations must be able to "see" the satellite in order to pass signals to each other through the "bent pipe". A satellite in geosynchronous orbit can see almost half the earth -- and an earth station anywhere within its field of view can also see the satellite. While there may be cases where a satellite is used to connect only two earth stations, a more typical use is to connect dozens or hundreds of earth stations through a single satellite.

Satellite links between earth stations may be symmetrical -- that is, each earth station may send and also receive traffic to and from the satellite. Or the links may be asymmetrical with some antennas sending, others only receiving -- and some doing both, all in the same network.

Satellites are used in the U.S. to distribute cable TV programs. A single earth station may transmit 20 or more programs, passing them all to one satellite which in turn might retransmit the signals to 1000 or more cable TV systems. Recently, the number of earth stations picking up cable TV programs mushroomed as many people bought backyard antennas which are estimated to number between one million and two million antennas.

Both NBC and PBS now use satellites to distribute their signals to their affiliated broadcast stations (about 150-200 each). Users like NBC and PBS do not need to be concerned about the so-called housekeeping chores involved with the satellites they use. Typically, they lease capacity on a satellite which belongs to someone else. The capacity of the "bent pipe" is made available to them and is kept in a given location in the sky by the owner/operator of the satellite system. All the user needs to do is aim his transmitting antenna at the satellite and line up his receiving sites to point at the same satellite. His signals must be broadcast on the right frequency at the right power level; aside from staying within these limits, the user is not concerned with controlling the satellite system.

The operator of the satellite on the other hand, is concerned with the whole system. Once the satellite is placed in the proper orbital slot, the operator, using a control console, monitors the location and health of the satellite. When the satellite drifts out of the "box" in the sky in which it is normally kept (usually a box measuring 0.10 in North-South and East-West coordinates), the operator energizes small thrusters on the satellite to impart momentum in the right direction to return the satellite to the box. The operator also monitors critical voltages, currents, temperature, etc., and may take certain actions to restore normal operation. If one transmitter on the satellite fails, for example, the operator may deactivate the transponder with the problem and turn on a backup replacement. Or he may use the same transponder, engaging a spare transmitter tube.

The operator may or may not have been involved in putting the satellite in orbit. Some operators such as Comsat have their own launch control centers (LCC). Intelsat has typically used Comsat's LCC to handle the satellite until it is placed in its final location. Comsat and other satellite operators have relied on NASA for the actual launch of the satellite. (The French Company, Ariane Space, offers launch services from their site in French Guiana near the equator.) NASA's launch involves the use of a launch control center in Florida -- they have a comparable control center in Houston - together with a world-wide network of tracking stations which keep the launcher and satellite in view essentially continuously and communication links to get orbital data back to the control center. The control center decides when certain commands are to be sent and, using the proper tracking antenna, passes the command signals to the vehicle/spacecraft at the proper time. NASA may put the satellite in final orbit or -- in the case of Comsat launches -- may pass control of the satellite to Comsat after putting it in grosynchronous transfer orbit. The transfer orbit is a highly elliptical orbit of about a 12-hour period. Comsat normally tracks the satellite for two or three orbits, and then fires the apogee motor on the satellite at just the right time.

If everything has been done properly, the satellite ends up in a 24-hour (geosynchronous) orbit, i.e., stationary over the equator. The only remaining step is to move it slowly into position in the "box," the desired permanent operating position in space. This is done by firing the small thrusters which can be used to nudge the satellite into position and to keep it there.

To establish a tracking network for its satellites, Intelsat makes arrangements with its member states to perform tracking services. Thus, the Intelsat network will include -- in addition to its Satellite Control Center and the Comsat Launch Control Center -- perhaps a half dozen tracking stations in such countries as the USA, Australia, Japan, Italy, and the Cameroons. These are chosen as being in locations which together can see the whole arc through which the launcher/satellite will pass while achieving the proper orbit. Private companies in the US have made various arrangements to put together a network of tracking stations and control centers for launch of their own satellites.

The system which we have described is based on joint use of several tracking networks. NASA can, of course, carry out all these functions for itself since it has satellites of its own which it must control.

4. The Chinese Network

China needs a complete network in order to be able to operate independently from other countries. Thus China needs a launch control center which can serve as a nerve center to do the calculations involved in determining the orbit. Orbital mechanics is a well-understood science and the actual determination of the orbit is done over a period of a few hours. Therefore, the LCC, by itself, does not have very demanding computer requirements.

For Comsat's first launch, for example, Comsat did not even own a computer. The person in charge of the launch at that time (1965) said he would have been very happy to have had a PC to use. He actually rented time on a nearby computer.

China has several tracking stations which she needs to feed location information and telemetry on the workings of the launcher and satellite back to the launch control center.

Richard Smith, NASA's director of the Kennedy Space Center, was recently in China with a U.S. group which became the first outsiders to see many of the Chinese facilities. Smith visited the new Chinese launch site at Xichang in central China where the US visitors were shown a single launch pad. (Mr. Jing at the Chinese Embassy said they were prepared to build a second pad if growth in traffic warranted it.) The US tour group also saw the so-called range control center, a local control center which would supply data to those controlling the launch.[32] There they saw a large data display room with seating for 20 or more. In the room were Chinese-built computers which they were told were used for processing data related to the launch, range safety, etc. Special attempts were made to keep everything clean. Computer disc drives, for example, were in small clean rooms inside the main control room.

The group also toured a nearby booster checkout facility. They were surprised and impressed with the cleanliness of this room. Visitors are particularly interested in such facilities because many of us who have been given tours in China were impressed by the apparent lack of clean rooms. In the facility they also saw the rocket, including the liquid oxygen-liquid hydrogen stage.

At Weinan, in northwest China, visiting US scientists were shown two control centers, one used for control of spacecraft while the satellite is being brought to its proper location in space, the other for optional control of the satellite once it is in orbit. The first center is called the satellite telemetry and control center. In addition to monitoring telemetry related to injection into orbit and controlling the maneuvers of the spacecraft, this center also has a coordinating role for eight other satellite tracking stations.

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[32] Craig Covault, Aviation Week & Space Technology, Aug. 12, 1985.

The range control center at Xichang apparently controls the actual launch, with Weinan taking over orbital maneuvers of the spacecraft. Once the satellite has been placed in proper orbit and positioned near its final destination, the Weinan ground station a few miles away takes over and controls the satellite. Assuming we have interpreted the roles properly, the Xichang range control center would correspond to NASA's center at the Cape, while Weinan mission control center (Satellite Telemetry and Control Center) would correspond to Houston. The Weinan ground station corresponds to the dozen or so facilities in the US which keep track of satellites in order for NASA, Comsat, RCA, Western Union, MCI, etc. to be able to position their satellites in proper orbit.

In China, it appears that facilities such as these belong to the military. China does not have a carefully defined and isolated civil space program. The launchers are built by the Ministry of Astronautics which apparently also builds missiles for the military. Similarly, the satellites are built by the Ministry of Astronautics. Mr. Jing in the Embassy says that although both military and civil programs are handled by the MOA, there are different divisions within the ministry for each.

5. Comparison of Chinese and American space technology

Without access to classified material, it is difficult to compare US and Chinese technology. Inferences must be drawn on the basis of partial evidence. Evidently the Chinese have decided that they cannot be taken seriously in the world market for launches unless they begin to treat potential customers as friends and open up their hitherto closed society. Permitting Richard Smith of NASA's Kennedy Space Center to tour their launch facilities and see their launchers was a major step in this regard.

The technology of the launchers, the launch facilities themselves, the scope of activities being carried out with four or five different types of satellites indicate that the Chinese are becoming a space power in their own right. The successes they have achieved speak for themselves. Their satellites do what they were intended to do. We know that they intend to move on beyond their present level of communications satellite technology because they are negotiating -- although sporadically -- for the purchase of advanced satellites from the West. Part of their strategy is to maximize technology transfer in the process of buying whatever they eventually decide to buy.

There is a debate going on, according to the Chinese Embassy's Mr. Jing, between those officials who say China doesn't really need to buy satellites from the West and those who say they do need to buy from outside. People from MOA and MEI (Ministry of Electronic Industry) believe that, given the resources, China can build its own satellites. Ranged against them, according to reports, are the user agencies -- MPT, Coal Ministry, Water Resources and Electric Power, and Railway Ministries who don't want to wait the five to ten years it will take for the native industries to produce sufficient capacity. But the fact that there can be a debate of such consequence speaks well for Chinese technology and for the self-confidence of their technical community.

There are many varying estimates of the lag of Chinese technology vis-a-vis US technology. The conscensus seems to be that generally, in space technology, the lag is 15 years or so. The lag in space technology is also usually judged to be less severe than in many other areas.[33]

6. The Role of Satellite Communications

China has stated their goal of achieving a modern communications system on a high priority basis. This was stated on many occasions, including the study team visit to the MPT (Ministry of Posts and Telecommunications) in February 1986.

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[33] China Inaugurates a Satellite Television Network. Harold Jacobson, United States Information Agency, April, 1986.

To achieve the goal, the Chinese expect to combine the best properties of different technologies. They will move quickly on all fronts of communications technology. They expect to use fiber optics to wire the inner cities, microwave links to tie nearby cities together and satellites to establish trunk communications throughout the country. Satellites will also be used as a major component of their broadcast system as mentioned earlier in this report. As for capacity of their system, they begin with a highly underdeveloped communications infrastructure. There are about 200 people in China for every telephone. There are about ten times as many TV receivers as telephones. Since a good communications system is essential to economic development, they intend to work very hard to improve communications. The satellite system they have discussed buying from the West could supply about 30,000 trunks for long distance service. This would be a major step up in capacity.

The amount of capacity needed for TV broadcast depends upon whether they decide to satisfy local demands. The Intelsat transponders can supply two TV channels nationwide. Since many countries seem satisfied to supply only two or three channels to their people, the Embassy's Mr. Jing was asked if these two channels would be adequate. He said there was also a need to make channel capacity available to each province to originate and distribute by satellite its own TV programs. This means there is a need for 29 transponders for TV alone, if carried to completion. Jing also said that one province had placed an order for 800 TVRO antennas in the West. These would be used to reach 800 towns in the province.

7. C-band vs K-band -- A Chinese choice

Much of the prolonged delay associated with the Chinese RFP (request for proposal) for DBS (direct broadcast satellites) has been related to Chinese indecision on the question of the relative merits of C-band and K-band.

C-band has been in use throughout the world for decades, both for microwave terrestrial links and for satellite links. Microwave telephone relay towers have been features of the international landscape since the '50s. Towers are located on high ground every 30 or so miles to establish broad-band links for telephone long distance service. They are also used for TV relay -- for example by a network (CBS, ABC, etc.) which wants to put the same program on the air from 100 or more TV stations nationwide. These relay links crisscross the country in various directions.

When commercial satellites came along, they were assigned the same frequency as the microwave links. To avoid interference, satellite earth stations were carefully located so that stray signals from microwave links could not be picked up by the earth stations. Frequently, this meant locating earth stations in remote sites, preferably in a hilly or mountainous area with shielding provided by the surrounding hills.

Satellites and microwave links learned to live with each other, but it was the latecomers -- the satellites -- which had to adjust to the problems of mutual interference. And satellite earth stations typically could not be located near the source of their revenue. The traffic meant to go out over an earth station was hauled out of town 30-100 miles over microwave links and then sent out of a carefully shielded earth station.

Then K-band was opened up. K-band is roughly twice the frequency of C-band. K-band has several advantages and a few disadvantages as compared to C-band. First of all, it is a new technology. C-band systems, having been in service for years and years, have been through the learning curve cycles and so the techniques are well known, and prices for C-band equipment have fallen over the years. K-band, being relatively newer, does not enjoy the learning curve advantages, there is not as widespread a group of technicians who know how to repair the equipment, just as there is not widespread knowledge among engineers of how to design systems and components. All this is changing with time -- and in perhaps five or ten years, the advantages of C-band over K-band will have largely disappeared.

In our dealings at international meetings with third-world countries, these same questions surface. The advanced countries, led by the US, have said that there is no shortage of frequency available that there is new spectrum being opened up all the time. But the new spectrum requires knowledge of how to operate at K-band -- first, Ku-band, and eventually Ka-band. So the third world countries have frequently said that the advanced countries should move into the new frequency bands and leave the old tried and true ones to them.

C-band, then, has the advantage of familiarity for the engineers and technicians who know how to use it. It also has the advantage of freedom from weather effects. As we go toward higher frequencies, rain attenuation becomes more and more important. At C-band, rain is almost never a problem. At K-band, the next higher band, rain during heavy thunderstorms is definitely a factor. The total time of outage may be only ten or so hours per year, but for some types of service, this can be important. The way to alleviate the problem is to build a system with perhaps a figure of two safety margin, i.e., using twice the power (or antenna size) which is needed in clear weather. This of course adds to the cost of the system.

The advantages of K-band are that it is easier to form narrower beams at K-band and there is less congestion. There have been problems of siting C-band antennas in or near cities because of microwave link interference. Since microwave links have not been approved at K-band, one can locate K-band earth stations anywhere including at downtown sites. This saves the cost of hauling traffic from downtown to remote sites. It also has security advantages in that the customer does not have to worry about the link between his place of business and the earth station being tapped by unfriendly people. Of course, the satellite link itself can be intercepted, but this can be dealt with by techniques such as bulk encryption.

The higher frequencies of K-band permit either the forming of narrower beams -- which permits the use of lower power transmitters -- or the use of smaller earth stations with all the advantages thereof. One advantage is cost. The smaller dish is cheaper to build and install. Another advantage is aesthetic. Many neighborhoods do not want giant antennas in every yard.

Also, because of congestion in the geosynchronous arc where these satellites must be located, we have gone to two degree spacing at C-band. This requires a better antenna on the transmitters' earth stations -- to prevent sending energy into a nearby satellite. It also requires accurate station keeping on the part of the satellite itself. Furthermore, because there is not yet similar congestion at K-band, satellites can be spaced farther apart.

There is finally the question of ITU approval. The International Telecommunications Union is a UN-agency which deals with frequency and geosynchronous "slots" issues. The ITU tries to maintain discipline in frequencies and slots so as to avoid interference between signals emanating from different countries. In spite of frequent conflicts and differences, ITU has done a remarkable job of resolving issues in order to reach agreement on what types of service will use what frequency bands, etc. ITU has said that C-band will be used for microwave links and for point-to-point satellite services. It has said that S-band and K-band will be used for direct broadcast service. Countries can of course use frequencies in ways not approved for general use if they confine the signals inside their borders. This has permitted China to contemplate the use of C-band for their own domestic DBS service, even though China has said that eventually they intend to move DBS service to K-band.

Actually, China's definition of DBS service is not quite what we in the US mean by the term. Here, we anticipate DBS service to the home and there are 75 million homes in the US. In China, it is assumed that DBS service may be supplied to individual villages and apartments. There is no way of going to the one or two hundred million homes in China, many of which exist at a subsistence level with no prospect of the amenities of modern life (including electricity) in the near future. This means that DBS in China is essentially more like satellite service to TV cable systems in the US, all of which are fed by satellite. These systems number in the thousands -- perhaps five to ten thousand. Feeding these systems by satellite is done at C-band in the US.

We have said that DBS will operate at K-band, but so far no one has deemed it financially profitable to offer this service. There is talk of such service in Japan and Europe but that has not happened yet, either.

The internal debate in China has apparently been resolved. The Chinese say they will go ahead with a C-band system which will be used for the foreseeable future,[34] perhaps seven to ten years, or one satellite generation. This will allow them to employ their C-band skills in earth station design and construction. It leaves open whether they will decide to build their own C-band satellites or whether they will buy a more advanced design from the West. They were expected to make that decision in March 1986. But so far, no RFP has been issued which would make it known officially in what direction they will go.

An advantage accruing to C-band is that satellites have been built recently which use solid-state transmitters. This eliminates one source of uncertainty in satellite lifetime -- the life of the TWT (traveling wave tube) transmitters. A typical satellite has 15-30 TWTs on board. While C-band TWTs have become fairly reliable, there is relatively less experience with K-band TWTs, and there is essentially no good experience on the use of high-powered K-band TWTs in orbit. Low-powered (10-20 watt) tubes have been used in K-band satellites for six to eight years, but DBS planners in this country have counted on using high-powered TWTs (100-200 watts) to permit the use of even smaller earth stations. Typical designs have centered on antennas of about two-foot diameter. While China does not intend to build earth stations by the millions, and hence would feel little pressure to go to such high-powered TWTs, the lack of experience in orbit with such high-powered tubes has been one more source of uncertainty in planning DBS systems. The reason one can think of using such high-powered tubes at K-band is that the orbital arc is relatively free of similar satellites and they can be spaced far enough apart so that interference between satellites is not a problem. This is not so at C-band.

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[34] The C-band versus K-band debate within China is well known to suppliers and observers including the commercial and science officers at the US Embassy in Beijing who were interviewed by the study team. The decision for C-band was confirmed to the team by the Satellite Office Director of SSTC in Bejing and the First Secretary for Science at the PRC Embassy in Washington.

To sum up in a few words:

Advantages of C-Band for Satellites

1. An old and proven technology.
2. Less rain attenuation.

Disadvantages of C-Band Satellites

1. Orbital congestion.
2. Interference problems from microwave towers/links.

3. Power limitations because of potential for interference.

4. Need larger antennas for a given size beam.

Advantages of K-Band Satellites

1. Allowed to radiate higher power.

2. Can use smaller (thus cheaper) earth stations.

3. No interference from microwave links (therefore can locate near downtown, on top of office buildings, etc.)

Disadvantages of K-Band Satellites

1. Technology not as well established (engineers/technicians not as well trained in it).

2. Components can be more expensive.

3. Rain can be a problem -- so system must be somewhat over-designed.

B. CHINA'S SPACE COMMUNICATIONS--PRESENT STATUS AND FUTURE GOALS

1. The telecommunications and telecommunications satellite priority

Chinese planning authorities have identified communications (with energy and transport) as one of the three major infrastructural weaknesses that imperil China's all-out drive for economic modernization. In the Seventh Five-Year Plan (1986-90) the Chinese leadership once again acknowledges the urgent need to develop communications if China is to approach its year 2000 target--quadrupled production in two decades.[35]

Yang Taifang, Minister of Posts and Telecommunications, states that "telecommunications, a weak link in the national economy, will be shielded from a planned overall tightening of state investment in capital construction during the next five years . . . the state will invest about ten billion yuan [roughly three billion dollars], almost double the state investment in this field in the Sixth Five-Year Plan . . . planned investment will include setting up a domestic telecommunications satellite system . . . ."[36]

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[35] "The Seventh Five-Year Plan," Bejing Review April 28, 1986. The introduction cites these three sectors for accelerated development. Premier Zhao Ziyang's report on the plan, Bejing Review (hereafter "BJR") April 21, 1986, also groups the three sectors under "Basic Tasks of Development." Hiroshi Yoshida, JETRO China Newsletter (61 (1985), cites telecommunications development as a major task in the Sixth FYP, and again in the Seventh FYP, alongside transportation and energy. He cites a Party Central Committee document setting forth policy suggestions for the Seventh FYP. He says this document identifies the three sectors as "areas known to be stubborn bottlenecks in Chinese efforts to develop the economy." U.S. Embassy, Bejing, September 1985. Telecommunications Sector Analysis, says the Chinese leadership continues to consider this sector as one of the top three priorities in the modernization drive.

Emphasizing the need to use China's space program for direct support of economic development, the Chinese Embassy Minister Counsellor for Science and Technology says that China cannot spend too much on space, when there is so much that China must do on earth. However, since satellite communications provides benefits for the whole Chinese people, he continues, then China will continue to develop it.[37]

And what kind of a priority does the satellite telecommunications segment enjoy within the priority communications sector as a whole?

The State Science and Technology Commission (SSTC) and the Ministry of Posts and Telecommunications both subscribe to the three-part system of telecommunications development we have mentioned -- fiber optics for short distance communication, microwave for medium distance, and satellite communications for long distances.[38] There is no suggestion of telecommunications load balancing or the need for parallel systems. In fact, there is no Chinese plan in evidence for balanced, integrated telecommunications development, although China can ill afford the continuation of a situation in which various telecommunication modes and telecommunications systems are permitted to grow without coordination.

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[36] Minister Yang Taifang in the China Daily, December 4, 1985.

[37] Lu Jing Ting in a study team interview at the Chinese Embassy, February 7, 1986.

The National Council for U.S. China Trade reported in 1984 that Chinese communications authorities have come to realize the difficulties involved in achieving a more thoroughly integrated national telecommunications system and were expected to seek foreign assistance to improve network design and planning.[39] The foreign assistance will apparently be sought from the United States, and perhaps other countries. The original draft protocol[40] for the promotion of U.S.-China scientific and technological cooperation in telecommunications, was specific as to this point. Under the protocol, a U.S. Government/business group would perform an economic and management analysis of China's telecommunications needs, and study the need for development of a long-range Chinese national telecommunications plan based on

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[38] Interviews, Wu Jiakiang, China Broadcast Satellite Corp. (CBSC), February 19, Bejing. Yun Jin, Ministry of Posts and Telecommunications (MPT), February 20, Bejing.

[39] Madelyn C. Ross, "China's Great Leap Skyward," CBR, January-February, 1984.

[40] The protocol, finally signed in May 1986, is discussed further in D. INTERNATIONAL COMPETITION 2.c. U.S. Agency Support.

China's telecommunications requirements.[41] Although Beijing says it still needs this study, it was omitted from the final protocol in favor of a more general statement of the U.S. Delegation's purpose. The omission is not surprising in view of its open acknowledgement of Beijing's communications planning difficulties.

When the U.S. group conducts the study, they will find that China's telecommunications planning is complicated by the existence of several separately controlled and administered telecommunications networks. Ministry of Posts and Telecommunications (MPT) officials ruefully admit that the separate networks of the ministries of coal, petroleum, rail, electric power and national defense, all came about as a result of the MPT's failure to provide for basic communications needs.[42]

The U.S. Group will also be likely to find a good deal of enthusiasm among Chinese planners and public alike for rapid expansion of space communications. The enthusiasm will not be fully shared by the MPT whose officials are concerned that concentration on satellite capabilities will lead to down-grading of the requirement for further expansion of the existing microwave system[43] which, unlike the satellite system, is fully under MPT control.

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[41] Draft protocol.

[42] Interview. Yun Jin, Deputy Director, Department of Science and Technology, MPT, February 20, 1986, Beijing.

Despite the lack of any official prioritizing as among telecommunications systems, satellite communications are likely to have a strong claim on use of limited communications development funds. For one thing, satellite communications are on the cutting edge of new telecommunications technologies. Highly visible successful satellite launches are evidence of China's technological progress which can be displayed before China and the world. A satellite launch, even an experimental launch, boosts national esteem and adds domestic constituents for priority development of this mode of telecommunications. It is furthermore, palpable evidence of achievement in the third (science and technology) of the "four modernizations" which underlie China's drive for development. It is evidence to which the current Chinese leadership can gratefully point with pride.

After the launching of China's first communications satellite, ST-1, in 1984, the Beijing Review trumpeted: "Everywhere the Chinese people are reported overjoyed with the successful launching...It will greatly inspire people throughout the country to strive for new victories in socialist construction."[44]

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[43] Ibid.

Another reason for an unofficial satellite communications development priority is the central role satellite transmission plays in the rapid development of China's national television. Not surprisingly, three-fourths of the Intelsat satellite capacity leased by China is devoted to television.[45]

Bad as China's telephone system is, and it is very bad, the Chinese public undoubtedly gains much more psychic satisfaction from good satellite TV reception than it could gain from improved telephone service via microwave or fiber optics. This is especially true of that large part of the Chinese public which never had, in the past, either TV or telephone, but now has access to TV and would find it difficult to live without it.

The propaganda possibilities of the countrywide spread of satellite TV is not lost on a government which needs to retain control over popular attitudes. In Part A we noted official acknowledgement of nation-wide communications as necessary to enhance political c ntrols and national security. Judicious use of TV programming w ll help the government condition the impact of the outside world the Chinese public. Americans are aware of the public opinion orming influence of skillfully-edited TV programming.[46]

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[44] BJR, May 7, 1984. The Chinese press gave wide coverage to the visit to China in June 1985 of U.S. (Shanghai-born) astronaut Taylor Wang, shortly after his participation in the Challenger-17 mission. In China, astronaut Wang declared: "Chinese scientists have worked hard...and have now constructed the whole comprehensive system for space scientific research and development on their own. It is amazing." China Daily 7/10/85.

[45] Intelsat statistic.

Satellite tel ision in China is not only a powerful tool of entertainment and ntrolled information, for many Chinese officials its para unt importance is its contribution to public education.[47] Spea ng to an international television symposium in Montreux in 1985, e President of the China Broadcasting Satellite Corporat n pointed out that the foundation of the success of the "fo modernizations lies in the popularization of education and in t raising of the scientific and cultural level of the whole natio " He noted that in 1984 alone there were over a million (mostly gher education) students in the Central Radio and TV University, nd that in 1987 the higher education students reached by this me um would more than double those in the regular universities. He a o noted that 2.4 million "unqualified" teachers had been ached by TV, and declared that "to cover China's vast terri ry of 9.6 million square kilometers (70%

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[46] At the same ime, the spread of TV can put government control at risk, b opening backward and previously closed-off sections of China a variety of impressions of the outside world.

[47] One of the o transponders China has contracted to buy from Intelsat will e devoted exclusively to educational broadcasting.

mountainous) with high quality TV and radio programs, the introduction of satellite is the only solution." The CBSC president went on to say that "to use satellite for the realization of national radio and TV coverage for education and recreation will have invaluable social, cultural and economic effect in China."[48] Arriving at a similar conclusion, the World Bank has loaned $50 million to the China Television University project.[49,50]

2. China's satellite communications goals

Although China has, as yet, no comprehensive communications development plan, it seems clear from the foregoing that satellite communications development will play a pivotal role in the evolution of China's communications system. A generally accepted goal for the system is a comprehensive, good quality, national radio and TV network by the year 2000.[51] In subscribing to this goal, CBSC President Xu, at the Montreux conferences conceded that China has a long way to go because, by 1984, the TV network only covered an area inhabited by 64.7% of China's population, and the technical quality of relay broadcasts was often poor.[52]

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[48] Xu Zhongming, "Planned Broadcasting Satellite System in China," to the 14th International Television Symposium, Montreux, June 1985. According to the China Business Review (Jan.-Feb. '84) China's Universities have space for only 4 percent of China's high school graduates.

[49] Madelyn C. Ross, "China's Great Leap Skyward," CBR January-February 1984.

[50] Minister of Defense, Zhang Aiping, has observed that China's satellite system is an instrument of neighborliness because "it will provide coverage, not only for all of China, but also for some friendly neighboring countries and regions. This will establish the groundwork for establishing satellite communications linkups between China and these countries and regions. Beijing Review, April 8, 1986.

China's communications satellite development goals relate directly to development of China's space program of which it is a part. China's space officials maintain that China has now emerged from a prolonged initial experimental period to a new period of space technology applications.[53] As indicated in the preceding technical background, China is proceeding with development of carrier rockets which will provide increased satellite lift. By 1990 China expects to have a carrier which will lift a synchronous satellite weighing up to two metric tons.[54] The power of this next generation of rockets would thus be equivalent to the Saturn

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[51] U.S. Embassy 1985 "Telecommunication Sector Analysis."

[52] Xu Zhongming, "Planned Broadcasting Satellite System in China," International Television Symposium, Montreux, June, 1985. The Chinese debate over the merits of C-band versus K-band must have been going on at that time, so it is worth noting that in this speech Xu goes on to compare the technical qualities of C-band versus K-band and concludes that K-band is more suitable for China. The study team was told, on good authority, that C-band had been found more suitable after all. Comrade Xu has since been removed as CBSC president.

[53] Jing Zhaogian and G. Lynwood May, "China's Developing Space Program," Signal, February, 1986.

[54] IBID.

I class used by the U.S. twenty years ago.[55] Looking even farther ahead, China's space officials have stated that the next objective is the launching of reusable vehicles and a space station.[56] The developing communications satellite program will be carried forward as part of the broad expansion of the space program.

Many related parts of the program are reportedly moving ahead. Satellite development and test centers are adding substantial new facilities to upgrade Chinese capability in design of operational space systems and in the preflight checkout of spacecraft. A large new solar simulation laboratory in Beijing will help improve altitude control, a Chinese weakness. At Weinan, the mission control center is undergoing a complete renovation, together with the installation of a new computer center which will bring the facility in line with the technology of the 1980s.[57]

The next communications satellite designed and built in China, China's third, is to be ready in 1987. U.S. technicians, who have visited the Chinese facility building the satellite, describe it as an improved version with a split beam antenna and complete microwave capability.

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[55] Craig Couvalt, AWST, July 22, 1985.

[56] AWST, July 8, 1985.

[57] "Test Centers Near Beijing Expanding," AWST, 7/15/85.

At this point, it would be guess work to suggest the interrelationship, within China's future network, of imported satellites to Chinese satellites, and to satellite capacity rented or purchased from Intelsat. As we indicated above, the Chinese Embassy's first Secretary, Jing Zhaopian, maintains that, as more satellite capacity becomes available, the individual provinces and Beijing and Shanghai will each want to program their own satellite transponders.[58] So the network will be both extensive and intensive. Chinese officials continue to say they intend to import some advanced satellites together with the technology to build them. Besides the satellites themselves, there are many other kinds of communications satellite technology which China will need to import as the network grows.

3. China's need for satellite communications technology transfer

The United States has been fortunate in having five delegations of highly-qualified individuals visit China's space installations and production facilities in recent years. Findings of these delegations have been reported.

The delegations, widely separated in time, were: 1979 - American Institute of Aeronautics and Astronautics (AIAA), NASA; 1985 - AIAA, NASA, People to People. Although the Americans were not able to see a number of things they wanted to see, they did come away duly impressed with China's technological advances. They also acquired some ideas as to China's need for technology imports to support an up-to-date program of carrier rocket and satellite development.

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[58] Study Team interview, May 12, 1986.

In a 1980 China Space Report, an early AIAA technical assessment, expressing admiration for what the Chinese were doing on their own, said: "In many cases our preconceived notions proved misleading. We were, in fact, surprised at the advanced state of development in several technological areas based on work conducted in China in the last two or three years. In areas such as in the development of microwave solid state devices and techniques, the research appeared to be advancing at a pace with that in the U.S. Certainly any sweeping observation that China's aerospace technology is 'n' years behind the U.S. must be made with care. In truth 'n' is anything from zero to ten or fifteen years. It might even be negative in a few areas."[59]

The 1980 AIAA impression was updated in 1985 by Craig Couvalt, Aviation Week and Space Technology's senior space editor, who returned from a People to People delegation to write: "Using rudimentary techniques and with almost no outside help, the Chinese have demonstrated all the capabilities necessary to conduct a space effort important to national prestige, defense and their economy."[60]

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[59] Quoted in Bradley Hahn, "China in Space," CBR, July-August, 1984.

The U.S. delegations found, however, that China's basic "self-reliant" development, which owes much to ingesting technologies available in free world technical data, left a number of areas where materials and systems needed upgrading.

The Chinese told the members of the 1985 People to People delegations they need help[61] with:

injectors
acoustic resonators
satellite tape recorders
gyro systems
digital computers

The delegation members described weakness in the following:

high temperature metal coating to prevent oxidation
rocket propulsion technology
low noise amplifiers

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[60] Craig Couvalt, "Contrasts Across China," AWST, July-August, 1984.

[61] Derived from series on the People to People delegation appearing in AWST, July-August, 1985.

Problems observed in technical approach included:

- insufficient redundancy
- no routine use of dual seals in rocket motors[62]
- insufficient testing to insure engine combustion stability
- use of statistical analysis to form the basis of operating principles
- poor arrangement of production facilities

In addition, the following[63] were included in a Chinese shopping list for a Bejing trade show planned for early 1986:

- space positioning equipment
- tracking radar, telescopes and laser rangefinders
- cadcam equipment
- electronic network analysis equipment
- oscilloscopes, electric current meters & recorders
- x-ray stress analyzers
- laser interferometers
- ultrasonic detectors

These lists, based on limited contact and observation, are only an outward indication of the type of transfers required to update a technology which is, on the whole, ten to fifteen years behind that of the advanced nations.[64] Although he found "isolated pockets" of up-to-date technology, NASA's Chief Engineer, Dr. Milton Silvera agreed that the Chinese program as a whole was quite backward. Recounting his 1985 visit, he said that "the few payloads we saw were so basic and crude that it was difficult to establish they were flight hardware.[65] The American observer groups were agreed that China's modernization needs extend beyond payload to the whole gamut of launch, tracking and control.

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[62] The observation about seals was made by a U.S. group before the Challenger disaster.

[63] James K. Gordon, China Boosts Effort to Acquire Technology Aerospace Equipment, AWST, May 27, 1985.

Backward as it is, China could, in fact, go on gradually building a satellite communications system using heavy, relatively inefficient and short-lived satellites. Through fee world technology stored in accessible data banks and open technical literature, or by covert sourcing through the Hong Kong back door,[66] China could continue to make limited technological advances in the future, in the same way that it has in the past. Yet second-hand technology transfers would only tend to perpetuate technological lag. Without transfers of state-of-the-art technology from developed countries, China would not be making the technological leaps she needs to make if she is to narrow the technological gap which keeps China behind the advanced countries. But China has already made a large resource investment to produce a satellite acclaimed as proof that China has the capability to move into advanced technologies. And China is offering to provide competitive space services on the international market. So it seems unlikely that China would avoid the import of modernizing satellite technology, and settle instead for continuance of technical inferiority in space communications.

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[64] The U.S. observers found Chinese laboratory equipment to be generally 25-30 years behind.

[65] 1985 report on People to People Mission to China.

[66] See Bradley Hahn, "China in Space," BJR July-August, 1981, for comments on China's technology sourcing. Another source were the overseas Chinese technicians who returned to China to use their foreign training in the space program. Their expertise is not now so fresh as to be important to further program development. Chinese students currently in the U.S., and presumably in other countries, do not have wide technology access.

Dr. Silvera's 1985 report substantiates this view when it concludes that China's space industry, no longer in its infancy, has to look outside for technology that will help it maintain its momentum. "Having reached the conclusion that they cannot advance much further by themselves, they are eager to learn from those nations that have well-developed space programs... The Chinese are extremely anxious to initiate a technology transfer with the U.S."

The central focus for China's near-term communications satellite technology transfer has been, and still is, the proposed acquisition of several imported satellites valued up to $200 million. China's apparent need for the satellites, and China's search for the appropriate supplier, goes back to the late 1970s.

In 1980, the purchase decision was postponed for the first time.[67] By 1984, Chinese authorities had apparently decided on a high-tech, Ku-band direct broadcast satellite. Comsat was employed as a technical consultant and an RFP issued.[68] After proposals had already been received, the Chinese authorities apparently began to question their own decision on the appropriateness of the Ku-band satellite. The RFP was suspended.[69]

For a time after the RFP was suspended, the Chinese discussed with the U.S. Trade and Development Program the possibility of a $200,000 feasibility study on the use of satellites in China.[70] As indicated below, however, the study team was informed in Beijing that since the Chinese have made up their collective minds for C-band, and since a new RFP is to be issued soon, there would be no need for the TDP study.

The controversy stirred up by China's prolonged indecision on satellite imports is important because it goes to the very heart of issues such as China's capability to select appropriate technologies, and China's relations with foreign technology suppliers--issues which will be discussed in more detail in the following sections of the study.

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[67] Karen Berney, "Communications Satellite Program -- An Aborted Launch", CBR, March-April, 1981.

[68] Bradley Hahn, "China in Space", CBR, July-August, 1984.

[69] AFP from Hong Kong in Asian Wall Street Journal, July 15, 1985.

[70] OTA interview with RCA, November 7, 1985,

5. China as a Competitor

a) Selling launch services

China's entry into the world market for space products was covered by an announcement in the China Daily on June 13, 1985, many months before the Challenger disaster.[71] The sweeping offering of the Ministry of Astronautics covered design and manufacture of satellites and carrier rockets, launching of satellites with Chinese carrier rockets, establishing of joint space engineering companies and construction of ground stations.

The Chinese sales campaign was stepped up by Astronautics Minister Li Yue in October, 1985, after the seventh successful launch of an experimental satellite on the Long March 2. Describing China's technologies as "mature", the minister offered launching services and launch insurance at "preferential prices" together with initial stage backup service, including orbital control. Putting the best possible face on the commercial proposition, Minister Li said China's action "will give impetus to international economic cooperation and international cooperation in the field of aerospace technology, and duly contribute to upholding world peace and to benefiting mankind."[72]

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[71] China Daily, June 13, 1985

A subsequent PRC announcement explained that China's ability to offer low-price services was not the result of government subsidies. Cut rates were possible it was said, because of the "low cost of materials and manpower in China."[73] Launch insurance coverage provided by the China People's Insurance Company at 22% of the launching cost is also cheap as against the 38% offered by United States insurance companies.[74]

Initially, the Chinese entry into the market drew cautious comment. A NASA official who learned about the Chinese intentions during a visit to China in early 1985, declared: "They have a way to go to be able to truly launch commercial satellites. But, in a couple of years, I assume it will be possible."[75] After the Chinese announcement, the Far Eastern Economic Review found that: "Observers describe China as having a modest capacity which would at present limit payloads mainly to launching scientific or remote sensing satellites."[76] Aviation Week suggested that there would be: "Minimal interest in the development of geosynchronous payloads small enough for Chinese launch capability. There is a more solid market for carrier low-orbit commercial payloads".[77]

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[72] China's News Service in Chinese, October 26, 1985 (HK260920)

[73] Discover, New York, 1985

[74] Wall Street Journal, May 15, 1985

[75] John Conway, MIS Week, NY, March 31, 1985

On February 7, 1986, the Chinese were able to announce that they had their first potential customer. The Swedish postal service had made a launch reservation on the LM-3 for a small satellite to carry their Mailstar electronic mail system. The launch could take place two and one-half years after final agreement.[78]

Subsequent to the January 28 Challenger disaster, the China Great Wall Industry Corporation (sales agent for space equipment and services) on their April visit to the U.S., explained that they did not wish to exploit the U.S. accident, and did not plan to become significant competitors. China was, they explained further, simply interested in providing alternative facilities in the light of reduced U.S. launch capacity.

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[76] Far Eastern Economic Review, January 1986, page 56

[77] AWST, May 5, 1986.

[78] Ibid.

The Great Wall group called on, among others, Comsat, Western Union and American Satellite Corporation.[79] The others included Teresat Inc. in Houston. In May, the U.S. press picked up on a Chinese announcement of the signing of a letter of intent with the Teresat group for the launching of two "rescued" communications satellites which a 1984 shuttle mission pulled out of failed orbits in space. The letter of intent was later followed by a launch reservation for Autumn 1987.

The official Chinese announcement of the Teresat business possibility was a little premature and doubtless impelled by their desire to establish credibility. Teresat is in the process of obtaining financing for the purchase of the satellites from Lloyd's of London. Meanwhile, the American company is talking to possible customers about possible services. The Chinese will only handle launch insurance, so the rest of the insurance package must be arranged.[80] If and when Teresat buys the satellites (there are other U.S. companies interested in them), their export to China will still have to be approved by the U.S. Government.[81]

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[79] AWST, May 5, 1986

[80] AWST, 6/25/86

[81] The Office of Munitions Control will not prejudge applications, but they informed the study team that the application could be handled in routine fashion.

Teresat's previous business experience relates principally to the international televising of heavyweight boxing fights.[82]

Discussing China's long range marketing program, the Chinese Embassy's First secretary for Science and Technology foresees a growing number of possibilities, including custom production for customers abroad. He says: "The first step is to provide launch services to foreign countries... The second step is to provide telemetry and tracking services.... The third step is to design and produce spacecraft for foreign countries."[83]

To lend substance to its marketing activities, China found it necessary to go public with hitherto unpublished details of rocket capabilities and launch failures. As early as April, 1985, Chinese officials attending an Italian space symposium brought along documents containing details of the Long March family of launch vehicles. According to European industry officials, this provided the first detailed look at Chinese launch capability.[84] Then, in October 1985, at an International Astronautical Federation Conference in Stockholm, the Chinese provided information on their investigation and analysis of two principal launch failures.[85] The Chinese description of their failure analysis and design fixes served to enhance China's technological credibility.

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[82] Wall Street Journal, May 15, 1986

[83] Jing Zhaoquian, "China's Developing Space Program", Signal, February, 1986

[84] "China's Offering Space Launch Services", AWST, April 8, 1985

As the Chinese see it, it was "sheer coincidence"[86] that China came onto the satellite launch market with a rugged, unsophisticated, and apparently reliable booster at a time when more complex systems have been grounded, and there was a growing backlog of payloads looking for launch. Although China does not itself have a long and convincing history of successful launches, the hardware and technology that China employs is similar to those of an earlier technical generation that does have such a history. It is reported (Washington Post, July 14, 1986), for instance, that the U.S. Air Force has reclaimed, and will launch, a communications satellite from the 60's that has been hanging in the Air & Space museum for 15 years. For a launch vehicle, Air Force technicians will reach back into the inventory and refurbish a reliable Scout rocket of the same vintage as the satellite. (The Scout will be reconditioned with flight-qualified second hand parts and total savings were estimated at $10 million). Air Force reliance on 20-year-old technology makes China's suggested space communications partnership with the U.S. seem less like an association of technical unequals. It does not mean, however, that China can stay in the market by continuing to rely on older technologies.

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[85] "Chinese to Demonstrate Booster Reliability", AWST, October 28, 1985.

[86] "Sheer coincidence" are the words used by Wu Keli, Deputy General Manager and Senior Engineer of Great Wall Industries Corp. (the space marketing agency) in refutation of "Western press accusations" that China was taking advantage of U.S. and French failures. The Chinese are very sensitive on this point. (Beijing Review, June 16, 1968)

Commercialization of Chinese launch services gives China a chance to capitalize on a hard-won technology. And space is big business. The European launch vehicle, Ariane, earned $20 million for its owners on a turnover of $203 million in 1985. Earnings are expected to double in 1986. There are 30 launch contracts in hand for Ariane through 1988 with a value of $1.23 billion.[87] The crowded Ariane launch schedule calls for seven to eight launches a year. The Chinese maintain that they can handle up to 12 launches a year.[88] But if they could achieve this rate, and had reason for it, they would probably have to redirect production facilities now devoted to producing rockets for the Chinese military.

Beijing gives every indication of wanting to get into the market in a big way. The Vice Minister of Astronautics, Sun Jaidong, was being somewhat disingenuous when, in describing

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[87] Aviation and Space, Smithsonian, June-July 1986

[88] "Long march into space," Far Eastern Economic Review, 6/19/86

China's willingness to help out in the launch shortage crisis, he says: "I'm sure the U.S. Government will give us full support since we are working for the benefit of all mankind." Getting down to business, he said: "For customers who are concerned about the risk (of their technology being copied during a Chinese launch), they can bring in their own people and supervise closely the entire launching. We can even build special warehouses for their satellites (to insure total secrecy)." China, the vice minister, added, will also go abroad to launch.[89]

Acknowledging that China's current restriction to only light lifts eliminates a large part of the potential payload market, the Chinese told NASA in April, 1986, that they had begun definition of a Saturn-class heavy booster. The new booster, probably an improved CZ-3, would be capable of lifting up to 5000 kg into transfer orbit. It would be ready in the early 1990's.[90]

The addition of commercialization has strengthened China's commitment to continue technological development of the space program. It has increased the need for technology transfer to keep China in the market. In forcing China's space program out into the open, it has fulfilled a precondition for successful technology transfer. By making China more eligible, it has opened new possibilities for partnership with technologically advanced foreigners.

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[89] Ibid.

[90] NASA memcon 4/15/86

b) Technology transfers to a potential Chinese competitor.

China's leap forward in space communications provide another dimension to the standard question about the U.S. assisting the technical development of yet another potential Asian competitor. U.S. suppliers and Chinese officials gave the study team the same general reaction to the suggestion of Chinese competition. It was, in effect, that China is so far behind technologically that technology transfer, in technologically advanced areas like satellite communications, presents no foreseeable competitive threat to the market position of the advanced nations. An imported technology, as against an indigenous technology, takes much longer to master. By the time the imported technology has been adapted to Chinese conditions, the foreign supplier has moved on to other more advanced technologies.

The above argument has advocates among interviewees in principal U.S. companies concerned including Ford Aerospace, Rockwell International, General Electric and RCA. There were no dissenters. A relaxed attitude concerning possible Chinese competition in the space communications area also prevailed in interviews with U.S. Government agencies including DOD, State, Commerce, NASA and NSC. No one, for instance, contended that cheap Chinese labor might be used to China's competitive advantage in this high tech area. Some felt that problems of economic organization, and bureaucratic encumbrances, as much as technical backwardness, would retard Chinese development and blunt the threat of Chinese competition.

As the Chinese Embassy in Washington, the study team was told by Lu Jing Tin, the Minister Counsellor for Science and Technology: "Don't worry about us. We will never catch up with you. The U.S. and China should be partners in the development of space communications."

Downgrading the possibility of Chinese competition, Richard Abington, the President of G.E. China Company, Ltd., suggested the need for U. S. - Chinese cooperation. In a Hong Kong interview with the study team he said: "Telecommunications satellites is one area where we can work with the Chinese without having to worry about their working against us. We ought to have a program of set technology transfers to China at preset intervals."

C. FACTORS AFFECTING TECHNOLOGY SELECTION, TRANSFER AND ABSORPTION

1. China's "open" policy and technology transfer.

"Open wider to the outside world and link the development of the domestic economy better with expanded economic and technological exchange with other countries."[91]

"China will expend all the foreign exchange it can make to purchase advanced technology and equipment from abroad."[92]

Obviously, effective technology selection, transfer and absorption, is most likely to occur in a country which aggressively searches for appropriate technology, attempts to establish acceptable transfer terms, and works to create conditions within the economy for technology absorption. China is such a country.

The first quotation is from the introduction of the Seventh Five-Year Plan. The second quotation is from a New York speech by Vice Premier Yao Yilin, who was in the U.S. in May 1986 for a meeting of the U.S.-China Joint Commission on Commerce and Trade. Both quotations are illustrative of the current national policy of employing foreign (predominantly Western and Japanese) technology as an essential tool of development. It is a policy which has been embodied in a series of complex Chinese regulations on technology transfer. The policy has also been institutionalized in the establishment of the special economic development zones and open cities in which concessions are made in the hope of attracting foreign investment and technology.

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[91] Beijing Review, April 28, 1986.

[92] China Daily, May 21, 1986.

Confusion, arises, however, when observers of China's drive for foreign technology encounter the constant reiteration in Chinese statements of the need for "self-reliance." Because of the largely self-generated development of China's space industry, "self-reliance" is often cited in relation to space technology.

On the occasion of the successful February launching of the second Chinese communications satellite, party and government leaders cabled congratulations to the comrades involved which said, in part: "This shows that China has fully mastered the technology of manufacturing, launching, tracking and controlling the carrier rocket; that China's satellite communications has moved from the experimental stage to the application stage; and that we have made new advances in space and electronics technologies...That the communications satellite has been put into actual use is the result of your self-reliant and painstaking research and hard work and the energetic cooperation of the people of the whole country."[93] The self-congratulatory statement makes no reference to borrowed technology, or to any technological backwardness.

The Dean of the Chinese Aerospace Technology Institute cites self-reliance in reviewing China's space progress during the program's first two decades. "In the past 20 years and more, relying on China's own strength we have made such great progress in the space industry because we have a superior socialist system, the vigorous cooperation of all departments in the country, and a superior corps of scientists and technicians."[94]

On the surface, these public citations of the virtues and rewards of technological self-reliance appear to contrast with the frank, almost apologetic, statements on technological backwardness which are invariably made to foreign technicians by Chinese officials. It contrasts also with official statements of openness to needed foreign technology like those cited above. The Chinese Embassy's science counselor was expressing a fairly common Chinese view when he said (Section B) that China "will never catch up" technologically. In Beijing, the study team was told by a director of the China Association of Science and Technology that

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[93] Beijing Xinhua, 20 Feb. 1986.

[94] Sun Jaidong, "China Enters Era of Space Technology," Beijing, Aerospace Knowledge Magazine, November 6, 1984.

China must have technology transfer in the technical area of space communications if China is to maintain a position among the world leaders in technology.[95] Chen Rongying, official of the China Society of Astronautics, said that China had done well enough developing satellite communications on its own, but has reached the stage where technology transfer is definitely needed if China is going to continue to move ahead.

So why the apparent dichotomy between Chinese insistence on self-reliance and China's declared need for technology transfer? The answer lies in what the Chinese mean by "self-reliance." The current Chinese leadership means self-reliance in the sense of freedom from outside control, and not self-reliance in the sense of isolation, or freedom from outside influence.[96] Within this meaning, selected, successful technology transfers permit China to develop *mainly* through self-reliance. Without technology transfer, there would continue to be self-reliance, but development would be questionable. China is likely to remain open to technology transfer in satellite communications because China needs technology transfer and wants it to happen.

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[95] Mme. Wu Ganmei, interview in Beijing, February 22, 1986.

[96] The distinction is made clearly by Ross Terrill, "China in World Affairs" *Foreign Affairs*, January 1978.

2. Decision making for technology transfers and the satellite communications bureaucracy

a) A formidable bureaucracy.

The dynamics of the world's largest bureaucracy are such that lines of authority and the power of individuals are in constant flux. That is why there are so many China consultants, and so few of them are qualified. Within the overall bureaucratic structure, however, there are distinct ascending levels of authority through which a matter requiring decision moves upward until it reaches a level which is both qualified and willing to accept responsibility for a decision. Then, according to the principle of democratic centralism, implementation follows the same path down to the action unit.

At the top level of the governing Chinese bureaucracy is the State Council. (Attached chart). The Council approves of the economic development plans (five-year and annual plans) to which all economic decisions must relate. In order to insure that full attention is given to the requirements of science and technology modernization, the Council has established the Science and Technology Leading Group. The group brings together representatives of organizations within the bureaucracy with major program responsibilities involving S&T.

The plan itself is prepared at the next lowest level by the State Planning Commission in consultation with the State Economic Commission. The former pulls together the sector plans to form a balanced national plan. The latter has overall responsibility for plan administration. Because of their broad responsibility, these commissions stand slightly above other state commissions, which have more narrowly designated areas of responsibility.

At the next lowest level are the ministries (aeronautics to textiles) which are in charge of the product and service segments of the state economy. It is at this level, the level of the commissions, and the ministries to which they are related, that the program for China's telecommunications (and satellite telecommunications) is hammered out. This is the level at which the study is centered.

As the attached chart indicates, the space technology and satellite communications bureaucracy is formidable. The three commissions concerned (there are four other commissions) represent general civil interests (State Science & Technology Commission) and military interests (National Defense Science Technology & Industry Commission) as well as the special interest (State Education Commission) in educational television. The four ministries represented at the next level are considered the most important program agencies because all four are producers of equipment for satellite telecommunications systems, and three of them administer segments of the system.

At the ministerial level, the Ministry of Foreign Economic Relations and Trade (MOFERT), is listed because MOFERT is at least peripherally concerned with all foreign transactions. Within MOFERT, it is the Technology Import/Export Department which approves technology import licenses. Also listed are the ministries which, as operators of separate communications networks, utilize satellite communications.

On a separate line are the institutes and societies related to satellite communications. Through their respective parent institutions, the China Academy of Sciences and the China Association of Science & Technology, the institutes and societies provide a channel for the scientists and technicians to influence policy and program development. Grouped under the bureaucratic aegis of the State Science and Technology Commission, these non-governmental "mass" organizations, with their broad membership base, are the "grass roots" of the scientific and technological community. Academic and professional judgments developed therein are given weight by the inclusion in their membership of the top bureaucrats who themselves formulate policy and programs.

b) Principal agencies.

In view of the formidable character of the bureaucracy involved in satellite technology transfer, it was difficult for the study team itself to select the most appropriate agencies to be interviewed during a short field trip to China.

The host for the study team was CONSULTEC, the China Economic and Trade Consultants Corporation, a consultant group attached to the Ministry of Foreign Economic Relations and Trade, China's lead ministry for all economic relations with foreigners. As preparation for the visit, the study team sent CONSULTEC a list of all the agencies which appeared to have some relationship to policy and implementation of technology transfer in satellite telecommunications. CONSULTEC was asked to arrange appointments for the study team with the most influential of these.

CONSULTEC assembled a group of three Chinese government officials representing three agencies which presented themselves as being principally responsible for satellite technology transfer. Since the major technology transfer issue was that of continuing Chinese interest in importing several satellites, the officials concentrated on that issue and their related responsibilities thereto. A brief examination of the principals in the satellite communications bureaucracy starts with these three agencies.[97] After treating the rest of the civil agencies, the military role is treated separately.

i) State Science and Technology Commission (SSTC)

Although it shares some of the commission-level responsibility with the defense technology commission, SSTC is the highest ranking organization with direct responsibility for the satellite communications technology program. Lapses in SSTC's liaison with the State Planning Commission with regard to technology planning have been a matter of concern which the government has resolved by establishing a separate Planning Bureau of Science and Technology with representatives from both agencies (See Attachment). The arrangement provides for regular direct contact, and supplements the arrangement whereby the two agencies meet on matters of more general interest in the Science and Technology Leading Group.[98]

In a February interview in Beijing, Wu Jiaxing, Deputy Director, High Technology Department and Director of the Satellite Office said that he had undertaken responsibility for reorganization of satellite technology transfer after it had been found necessary to twice postpone satellite importation. Mr. WU made clear that SSTC was taking a leading role in implementing the policy of science and technology exchanges with other countries on satellites. (He had just returned from leading a delegation to the U.S. to press for a completion of a space science exchange agreement with NASA). He informed the study team that China had reached a decision that would permit it to move ahead with the procurement of C-band multi-purpose satellite technology from abroad. He said he was prepared to inform the U.S. officially that China would not, after all, need a feasibility study financed by the U.S. Trade and Development Program.

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[97] The Chinese bureaucracy is, as we have said, anything but immutable. The lineup of agencies responsible for satellite technology transfer has changed before and will again. The only thing that is certain is that MOFERT, an agency which does know the lineup, designated these three agencies as the principals as of May, 1986.

[98] U.S. Embassy UNCLASSIFIED telegram, February 26, 1986.

ii) Ministry of Astronautics (MOA)

The ministry is in direct charge of civil satellite development and deployment. Under the ministry, and its subsidiary, the China Academy of Space Technology, there have been established the facilities that design, manufacture and operate the satellite system. A marketing subsidiary, the Great Wall Industry Corporation, sells China's space capabilities abroad. Chen Shouchun, Chief Engineer, Scientific Research and Production Bureau, told the study team that, within the ministry, his bureau sets the conditions for technology transfer and cooperation with foreign countries which are subsequently approved by SSTC. Mr. Chen said that, in this capacity, he had long been an advocate of close cooperation with the U.S., an advocacy which had been greeted with only moderate success. (See "Chinese perceptions" under section D below.) Chen asked for U.S. support and encouragement for China's commercial launch efforts because China was only trying to help out where help is needed.

iii) China Broadcast Satellite Corporation (CBSC)

CBSC, a direct subsidiary of MOA, is the operator of the satellite system, and the purchaser and end user of technology acquired abroad. CBSC will prepare specifications and do the contracting for the expected satellite purchase. Wong Zhengchi, Vice President of CBSC, admitted to the team that when, in 1984, the RFP was abandoned because of internal differences over the technology to be imported, the corporation had been forced to reorganize under the supervision of the State Council. The previous corporation officers had to be relieved of their responsibilities because they had become publicly committed to procurement (K-band) which was not as suited to China's conditions as the alternative system (C-band).

iv) Ministry of Posts and Telecommunications (MPT)

MPT was left out of the group presented to the study team by CONSULTEC as the principals in the program for satellite communications technology transfer. Nevertheless, MPT, as producer of some system components and the major end user of satellite communications, has an important interest in the system's technological development and would have to be consulted in this regard. MPT can be expected to resist MOA pressures for satellite communications development at the expense of development of the existing terrestrial system which MPT administers. MPT's relationship to MOA resembles that of U.S. satellite users to U.S. satellite operators. When China signed a 1984 agreement for the lease of INTELSAT circuits, it was MPT as lessee who signed. MOA was unrepresented in the group, headed by PTT, which came to the U.S. to sign the telecommunications protocol.

v) Ministry of Electronics Industry (MEI)

MEI was also left out of the group of principals yet, as administrator of China's developing electronics industry, MEI controls production facilities which supply essential communications subsystems for the satellite program. MEI also produces satellite "dishes" which China includes in the space products it would hope to be able to market abroad. MEI would be consulted in satellite technology transfer decisions.

c) Other Involved Agencies

i) Ministry of Foreign Economic Relations and Trade (MOFERT)

The ministry's position as ministerial coordinator in matters relating to foreign economic relations and trade assures its involvement in the decision-making process for satellite technology transfer. The ministry's Technology Import and Export Department reviews and puts its chop on proposals for technology imports. MOFERT also influences technology import decisions through its participation in the Leading Group on Science and Technology.

ii) User Agencies

Aside from the Ministry of Radio and TV, the ministries listed below MOFERT on the attached organization chart are the ministries which maintain communication networks separate from MPT and use them to communicate between installations under their control. As users, they influence development of the government's satellite technology transfer program. Inasmuch as their communications networks have evaded central control through MPT, it is presumed that they will seek to establish satellite television services outside of these provided by MPT. The petroleum and electric power ministries are reported to be planning satellite ground stations[99] which would use circuits leased from Intelsat, or available from CBSC satellites.

iii) China Association of Science and Technology (CAST)

CAST includes representation of the whole of China's S&T community, both within and outside of the government, and inevitably influences S&T policy and government actions. CAST's membership counts all of China's 138 professional societies, including its 46 engineering societies. The association is pursuing an active role in opening up channels for exhange of S&T information, both within China and abroad. CAST also prides itself on its success in leading China into association with world S&T organizations, as part of China's opening to the outside world. Cast's schedule of conferences, technical seminars and exhibitions makes CAST a principal avenue for technology transfer to China. In addition to acting as the organizational center for technical meetings between U.S. and Chinese telecommunications groups, CAST is organizing a China Committee for International Space. The Society of Astronautics, a CAST member, will be principal organizer of in this committee.[100]

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[99] Bradley Hahn, "China in Space," BJR, July-August, 1984.

[100] An interview with Wu Ganmei, Director, International Conference Center for Science and Technology, CAST,

d) The decision-making process

What about the process of decision-making on satellite communications technology transfer? What factors enter in? What factors, usually important, are of lesser concern in this case?

Although differences over the precise technology to be sought are bound to arise, and differences over technological appropriatness can be deep and divisive, decisions on technology transfer in satellite communications technology are relatively less complicated than they would be for other technologies. Because satellite communications are of a uniformly high technology with a relatively narrow application, the selection process is less troubled by considerations which frequently trouble the process with, say, energy technologies. Technology transfer decisions are easier in satellite communications because:

i) Tension which exists between decentralization and centralized management and production in other technologies is reduced. Satellite communications system elements are produced and managed under central supervision. Jurisdictions not under central control may import some ground station equipment, but the bulk of technology transfer relates to production and management controlled from the center. There is no local, small-scale production to be harmonized; no technological balance to be established between industry leaders and laggards; and no threat of widespread unemployment as the result of the introduction of new technologies.

ii) Demand for satellite communications is constant and growing. There is no question of overproduction, consumer preference, or the influence of market forces.

iii) The capacity for strong, self-reliant space communications growth has already been demonstrated. There is nothing to be proved, and foreign technology can be accepted without endangering the principle of self-reliance.

iv) Importation is in a narrow technology area which is easily monitored and controlled, so overlapping technical imports by different agencies are not the problem they are in other technologies.

v) Argument over apportioning of program effort between basic and applied science does not apply. In this high tech area, advances in space science find immediate application in space hardware and systems.

vi) There is no stubborn defense of an ingrained, traditional technology by an attached bureaucracy which questions the need for high-tech imports. While defense of the maintenance of a balance with other communications technologies is anticipated, the absolute necessity to supplement terrestrial communications with satellite communications is accepted by all relevant Chinese authorities.

3. The military role

Not unexpectedly, the Chinese military have been deeply involved in China's space program from the beginning. The satellite communications portion, however, has been primarily a civil program; developed and maintained principally for civil purposes. While China's communications satellite program cannot be divorced from Chinese military production, use and benefit, an effort has been made to separate it from the military, just as the communications satellite program is separated from the military in the U.S. through NASA and COMSAT, and internationally through INTELSAT.

Maintenance of spearation is not easy. The complex of civilian agencies involved in China's communications satellite program has been described in some detail in the foregoing section. Very little is known, however, about the military agencies involved. Inevitably, the same rockets which China uses to launch its communications satellites have military versions with military payloads. Production of all rockets is the responsibility of the civil astronautics ministry, but U.S. observers have found that production is partially in military facilities. Part of satellite production may also be in military facilities but, since the satellites are not primarily of military interest, presumably a lesser portion than is the case with the rockets.[101] Rocket launches, and launch facilities, have been under military control, but use of the new open[102] launch site in Sichaun province gives China a central-south civil launch site, and leaves the northern launch pad for strategic purposes. The Weinan central satellite ground control facility was seen by U.S. visiting groups to be in military hands. Handling of communications satellite transmission, reception and distribution, is a civil activity.

Military influence in development of the communications satellite program is exercised through the National Defense Commission for Science Technology and Industry (see attached aorganizational chart). As its title indicates, the commission is the central point in the bureaucracy for control of military production facilities in China's space industry. The commission also exercises administrative control over launch sites, and several tracking vessels operating in the South China Sea. The official announcement of the successful February launch of an operational communications satellite was made through the commission. Military views on satellito communications technology transfer would be presented by the commission through the Leading Group on Science and Technology under the State Council.

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[101] U.S. observer groups have seen parts of civil production facilities for both rockets and satellites. They have been told that other facilities are under military control.

[102] After the February satellite launch, Premier Zhao paid tribute to "technical experts as well as commanders and fighters" for making "more and greater contributions to modernizing national defense and to our modernization program as a whole. (FBIS, Beijing, February 3, 1986). A Chinese correspondent noted the presence of the Defense Minister "personally directing launch operations" (Ibid 2/2/86).

To what extent would technology transfer for China's satellite telecommunications assist the People's Republic of China military development? In weapons production? In military communications? In military use of civilian communications?

Clearly, any transferred technology which contributes to the production, launch, operation and control of space vehicles is going to assist China's space weapons production, but the contribution may be of no special significance. The coordinating committee of free-world countries for export licensing to communist countries (COCOM) exists to prevent export of technologies with special military use and strategic implications. Presumably, licenses for export to China of technologies which fall into the military-strategic category would be rejected through COCOM screening, if not previously rejected by COCOM member nations at a national control level.

The Chinese military could certainly use improved communications.[103] Conceivably, Chinese production and application of low-altitude reconnaissance satellites (discussed in the technical section of the report) would be benefited by technology transferred for other types of communications satellites.

Furthermore, communications satellite technology which leads to general improvement in China's overall communications system, would assist military subscribers along with the general public. At the Chinese embassy in Washington and the state science commission in Beijing,[104] the study team was told that the Chinese military were not much interested in satellite communications because everybody could read the satellite traffic. Signals could be coded, of course, but the Chinese officials were right in that military use of the national communications system would not be a big factor. In the U.S., for instance, the military uses only about 5 percent of international leased satellite circuits, and less than that percent of domestic circuits. In war time, however, the military would have priority use of national communications.

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[103] Dr. Ramon Meyers, Hoover Institute, in the American Legion Magazine, July, 1985. Dr. Meyers says that, when the People's Liberation Army was "clobbered" while teaching the Vietnamese a "lesson," the main problem was a lack of reliable battlefield communications.

[104] Interviews with Jing Zhaopian, S&T First Secretary of the Chinese embassy, and Wu Jiaxiang, Director of the Satellite Office, State Science and Technology Commission.

In the long run, and in common with most other advanced technologies, communications satellite technology transfer, even a controlled technology transfer, is going to result in some strengthening of China's military capability. It is really a question of emphasis. To what extent does China intend to use acquired technology to build up the military?

For a dozen years, China has spelled out its modernization goals in four categories; the "four modernizations" -- industry, agriculture, science and + technology, and national defense (usually in that order). But that includes about everything. Can China's modernization really be pushed forward simultaneously across such a broad front?

For an authoritative Chinese answer, we have a June speech by party General Secretary Hu Yaobang. Addressing the British Royal Institute of International Affairs in London[105] on the subject "Where is China headed?", Comrade Hu launched into the question of the relationship between expansion of military strength and economic development. Since expansion of both would lay claim to huge investment from China's limited resources, Hu says the two are "mutually exclusive." "To tell you frankly," Hu says, "China lacks funds in launching the modernization drive and it is not possible today, nor will it be in the next several decades, for China to spend heavily on expanding its military forces."

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[105] Hu's speech is quoted in the Beijing Review, June 23, 1986.

Lest his remarks be misconstrued by China's potential enemies, the general secretary adds: Of course it is also necessary for us to import some advanced military technology with the sole purpose of strengthening our defense capabilities. But we are not going to squander our limited amount of foreign exchange on heavy purchase of military hardware." China, Comrade Hu explains, is going to follow "an independent foreign policy of peace" because China needs "decades, or even a century, of peaceful economic development."[106]

In his statement, Hu cites the June, 1985, decision to cut the size of the armed forces by one million, or one-fourth. He also refers to recent reductions in the proportion of defense expenditures within the national budget. In the seventh five year plan (176-1980) the rate of defense spending declines to 9.1 percent from 13.1 percent in the previous plan.[107]

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[106] Hu's remarks show how far China's leaders have come from the seige mentality of Chairman Mao, who spoke of the inevitability of conflict, and popularized the slogan - "Dig tunnels deep, store grain everywhere!"

[107] Armament factories under the Ministry of Ordnance in 1985 were devoting an estimated 31 percent of their capacity to production of civilian goods. The number is to at least double during the current five-year plan. Meanwhile production units

The limited Chinese interest in military modernization became apparent to Roger Sullivan, president of the National Council for U.S.-China Trade, who accompanied a U.S. military sales delegation to China in November, 1985. Writing in the March 1986 issue of the China Business Review, Sullivan said: "The Chinese seem to believe they are now in a period of relative invulnerability to the Soviet threat during which they can afford, with little risk, to follow the approach long favored by Deng Xiaoping: subordinating military development to economic development and reforming the structure of the PLA before attempting to modernize it." In other words, progress on fulfilling the fourth modernization - national defense - is to yield to the other three - agriculture, industry, and science and technology. And, according to Secretary General Hu, we are talking about a process which will spread over the next several decades.

Despite the present outward appearance of a China devoted to economic progress in a peaceful environment, China's developing Pacific rim neighbors remain apprehensive about a potentially aggressive China. They have expressed to a study team member their concern at the proposals, by the U.S. and other Western nations, to transfer to China weapons technology of a "limited, defensive nature." On the other hand, they could be expected to

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that produce mainly civilian goods will be gradually turned over to provincial governments and/or civilian ministries. (China Market Intelligence, National Council, August, 1986) favor Western programs for transfer of satellite communications technology (which assists China's opening to the outside world.)

Satellite communications has acquired a standing as an important instrument in the evolution of an intercommunicating world, and in the development of the peaceful uses of space. It is this international acceptibility that has brought to satellite communications the support of the programs of the UN, the International Telecommunications Union, the World Bank and INTELSAT. The non-aggressive character of satellite communications technologies can also assist in their being approved for export licensing by the guardians of strategic Western Technology.

4. Capacity to absorb technology

Lack of technical sophistication creates difficulties in absorbing technology in developing countries, and China must be included. The relatively advanced technical development of Chian's satellite communications program enjoys a partial immunity from these difficulties; a circumstance which makes the program a good candidate for technology transfer.

China is trying to come to grips with problems relating to integration of technology in the development process. Science and technology is the third of China's targeted four modernization. In a major overhaul of China's science and technology system, the leadership has concentrated on the problems of compartmentalization and the separation of science and technology from production. A lead article in the June 16 1986, Beijing Review entitled "Revamping Science and Technology System," outlines the task: "Promote the integration of scientific research with production and bring the role of researchers and technicians into full play."

Application of science and technology to production has not been so much of a problem in satellite communications. U.S. observers have even found research institutes undertaking major production functions. Compartmentalization, however, has been a problem; one which observers assign to technology management. Inexperienced management, shortage of technicians, and lack of infrastructure are the three problem areas with potential to threaten progress on satellite communications. Although none of these have prevented China's program from becoming an outstanding high-tech success, they could, individually or collectively, limit the effective application of transferred technology in further development of the program.

a) Technical personnel

We have been unable to uncover evidence of the total number of technicians assigned to China's satellite program, but obviously there have been enough technicians to keep the program moving. Clearly, it has been considered a crash program calling for an extraordinary national effort. A Chinese publication says that: "According to statistics, tens of thousands of people took part in the research and manufacture of the satellite. Several hundred factories and departments in more than ten ministries and commissions, and over twenty provinces, municipalities and autonomous regions shouldered tasks in research, experimentation and production. The scale of co-operation was unprecedented in China's history."[108]

Major credit for the program's is success is given to the older technicians who antedated the revolution. The Dean of the China Aerospace Technology Institute tells us[109] that: "In the space industry corps there is a group of old specialists who have made important contributions to China's space industry.[110] They have wholeheartedly, conscientiously and indomitably put in an enormous amount of hard work...There are also the middle-aged specialists, who were trained by the New China, who have done world class work."

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[108] Buying Review, No. 19, May 7, 1984.

[109] Sun Jaidong, JPRS, CST-85-004, 5 Feb 85.

[110] In "The Chinese Space Program," P.S. Clark, Journal of the British Interplanetary Society, Vol. 37, 1984, we are told that the most important persons in development of satellite carrier rockets were two Chinese pre-revolutionary graduates of the California Institute of Technology. Clark says the Chinese could begin a space program by combining knowledge of the Soviet and American Space Programs acquired by veteran Chinese technicians.

Likewise, the Minister of Defense, Zhang Aiping, attributes satellite program success "first of all to China's strong contingent of space scientists and technicians including a number of veteran experts." Next to be credited are the "middle-aged specialists and technicians" trained since the founding of the People's Republic. "They have done world class work in developing China's space science and technology."[111]

U.S. technical delegations to China have been uniformly impressed with the quality of the technicians assigned to the Chinese space program. If anything, they have found installations they visited to be overstaffed. They were surprised at the degree of accomplishment by dedicated technicians in facilities that are "old, dark, and rudimentary."[112] They were surprised too, that China's space, and space communications development had continued to take shape during the dark period of the Cultural Revolution (the late '60s and early '70s), a period when the JCCT itself was disbanded.[113]

It was the Cultural Revolution which crippled technical training for nearly a decade. In the Late 70s, when China emerged, there were not nearly enough trained technicians to support the new leadership's program of forced draft economic expansion. Although the space and satellite programs have so far been adequately supplied from the limited pool of qualified technicians, the programs will have to retain their priority among priorities if they are to continue to be spared the consequences of the shortage. Fortunately, the technology transfer in itself is unlikely to contribute to the problem because the Chinese will insist on technical training as an integral part of the technology package.

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[111] Sun Jiadong, JPRS, CST-85-004, 5 Feb 85.

[112] BJR, April 30, 1984.

[113] People to People delegation report and series in AWST, especially Couvalt article AWST, 8/12/85.

b) Management

In summarizing the experience of the successful 1984 communications satellite launch, the Chinese Defense Minister finds that a good deal of credit must be given to" socialist management." It is, he says, proof of the "effective Chinese system guiding scientific research. This includes establishment of a chief designer, a command system, and the combination of unified leadership and division of labor with individual responsibility." This system, he states proudly, was "invented by veteran revolutionaries."[114]

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[114] "How China Rjuns Its Science", Nature, 21 November 1985

The Defense Minister's assurance of the effectiveness of socialist management technology, even in the successful space program, is generally not shared by foreign observers. A 1984 article on the space program in the China Business Review finds that "limited coordination in the areas of project control, scheduling, quality assurance, and modeling reliability continues to slow progress. The lack of integrated management, rather than lack of funds, appears for the moment at least, to be the Achilles heel of China's space program."[115]

In a more recent look at the situation, Craig Covault, Space Editor of Aviation Week and Space Technology wrote in July 1985, that he had found in China a real problem of basic management skills. There is, he said, "no strong sense of space program leadership. It is a too compartmentalized to allow exchange of information necessary for development of high technology on a broad scale. Facilities working on the same program are not well coordinated."[116] Other observers suggest that the Chinese lack experience in such areas of technology management as sorting out critical elements and making critical decisions relating to research and development.

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[115] Zhang Aiping, BJR, April 30, 1985

[116] Bradley Hahn, "China in Space," BJR, July-August, 1984

Some knowledgeable Chinese are painfully aware of the lack of management skills. He Yan, Deputy Director of the Weinan Control Center, told the 1985 U.S. expert delegation that space program management coordination is an area in which China requires help. Furthermore, the Defense Minister's above-cited complacency concerning socialist management capability is also not shared by that other old soldier, Deng Xiaoping. This spring, the paramount leader told an Australian delegation that the two things China needs most to import are technology and management.[117]

Foreign assistance for Chinese management is the basis for the progressive establishment of management institutes by China's principal Western trading partners and Japan following the U.S. Government initiative in founding the Dalian Management Institute in 1980. Furthermore, the recently signed U.S.-China Telecommunications Protocol allows for U.S. assistance in telecommunications management.

Effective transfer of advanced space communications technology to China may require the inclusion of management skills in the technology package. Aside from wrapping management skills into a joint venture, however, this is going to be difficult to arrange.

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[117] AWST, July 8, 1985.

c) Infrastructure

Does China have the industrial infrastructure to support an advanced space and space communications program, and how does this affect technology transfer? The short form answer is that China does not, and it complicates technology transfer.

At least one observer says China does have the infrastructure. Bradley Hahn, in his 1984 China Business Review article finds that: "Unlike its other industrial sectors, China's space industry enjoys the latest in modern technology, the support of a comprehensive industrial complex, and a highly trained contingent of scientific and technical personnel."[118]

A 1985 Beijing Review[119] article describes the process whereby diverse industrial capability was brought to bear on construction of a test facility. In 1976, when China was emerging from the shadow of the Cultural Revolution, the environmental engineering and test center faced difficulties in building a thermal vacuum tank to simulate outer space conditions. Support was mobilized from all parts of the country. A special office was established, and personnel were selected from thirty factories and scientific research institutes to work on the project.[120] The test tank that resulted is said to be the largest in Asia.

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[118] Hahn is director of the Titusville, Florida, consulting firm, Hahn Associates International. CBR, July-Aug. 1984.

[119] AWST, July 8, 1985.

While this kind of task orientation of available industrial capability helps to explain China's remarkable progress in its space programs, it points up the lack of the dedicated industrial infrastructure which China needs to support a sustained, large-scale space program, and to effectively absorb a technology transfer thereto. Ford Aerospace, RCA and Varian, all of whom have spent some time and considerable money tracking opportunity in China's space program, have all remarked on the lack of supporting industrial structure.[121] They point to the lack of a certified supplier base for materials, parts, supplies and subsystems.

The Japanese (Jetro Newsletter 61, 1985) agree, saying that Chinese plans to reduce investment in telecommunications technology imports by relying on indigenous technology and equipment is infeasible. Conceding that Chinese basic research is well-advanced, the article insists that the country lacks the production technology to manufacture the precision equipment it needs for its telecommunications development.

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[120] It is not known what other priority projects were started of resources in order to feed this satellite program emergency.

[121] BJR, May 7, 1984.

China's infrastructural shortcomings can be rectified as the base of industrial support is built up over time. Meanwhile, as one U.S. supplier of technology observes, when U.S. designs with U.S. tolerances are introduced into the less sophisticated Chinese technical environment, it takes a long time before the transferred technology can be successfully adapted.[122] Chinese development is slowed in the process.

5. Searching for the appropriate technology

Before China's vigorous pursuit of its open policy of trade and economic relations with the industrialized democracies, it was not unusual for a supplier in a distant country to get a serious enquiry from a Chinese organization he had never heard of, and for a product he had never thought of marketing in China. The Chinese had learned of the product by sifting through catalogues of technical literature. After the Cultural Revolution, as China stepped-up its development, the Chinese search for appropriate technology moved into open commercial channels. Now, before final selection of important technologies, there is an extended, methodical investigation which includes multiple visits by delegations of Chinese technical experts to the production facilities of competing foreign suppliers where direct observation can be made of the technological capability being considered.

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[122] Martin Packard, Varian.

Despite recent improvement in direct commercial contact under the open policy, the Chinese selection process is still somewhat handicapped by China's long-standing, prior ignorance of world technology markets. Furthermore, some Chinese producers develop an exaggerated view of their own absorptive capabilities, a view which leads to importation of high technology without the know-how to put it in service.[123] Since China's technology needs are so broad, and there are a large number of foreign suppliers who have technologies that could possibly be used, the Chinese can be expected to engage in long, labored, and intensive technology quests which may end up with inappropriate technology, or the funds will run out, or the priority will change.

During the process of technology selection, an unhelpful dialogue frequently develops between the Chinese buyer and foreign suppliers. The Chinese say: "Tell us what you have that you can export and we might need." The foreign supplier replies: "First, tell us what you need, and we will see if we have it and can supply it." Normally, it requires the use of considerable commercial skills, money, patience, and goodwill, before the supplier eventually discovers what the Chinese need so that he can relate it to his production capabilities. Chinese unfamiliarity with technical markets has become an even larger problem with the growing decentralization of trade and the shift of much of the technology import responsibility out of the direct control of more experienced state trading agencies.

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[123] The National Council, in its pioneering 1979 work, Selling Technology to China, cites a number of examples (p. 96-97) of Chinese purchases of licensed technology which could not be converted into production. The practice has continued. A more recent example (cited to the study team) is that of a license purchased from Varian for production of aerospace equipment. The Chinese were unable to put the license to use and have continued ordering Varian's kits for the same equipment.

Then there is this other problem which results from the identification of two appropriate foreign technologies for a particular need and the attempt to determine which is most appropriate for China. That is the problem that arose when it was discovered that there are two importable telecommunications satellite system technologies, and both are appropriate in that either can propel China's space communications forward in a desirable direction. China's lack of an overall telecommunications development strategy compounds the difficulty of selecting the technology with the best fit. The long-standing controversy is so important for both the satellite communications technology suppliers and the potential Chinese users, that it deserves separate treatment.

6. Selecting A Satellite

With the issuance of a new, revised request for proposals (RFP) China's multi-year effort to select an imported communications satellite system may be nearing an end. The long process has been one of the more notorious examples of delay in import decision making in the recent history of China's trade with the industrialized democracies.[124]

We cited a number of normally complicating factors which do not apply to satellite communications technology transfer decisions because of the special circumstances of the satellite program. The fact that the cited factors do not apply removes a good deal of the complexity that could attach to Chinese decision making on satellite imports. Inevitably, however, there remain several fundamental factors, such as price and foreign exchange availabilities, as well as technical preferences, which can be compelling factirs, and which apply in this case.

We do not know what made China decide to build and buy satellites, rather than depend on leased satellite services, as many other developing countries do. Leasing would have been easier, cheaper and quicker. Indeed, as we have observed, China was forced to lease some circuits from INTELSAT in order to get the satellite communications program moving. There was some domestic opinion which favored building a system based on leasing. A 1984 article on "China's Domestic Satellite Communications" in the Chinese official publication, Telecommunications Technology, says: "Organizing a domestic satellite communications network by satellite leasing can effectively change the inadequacy of our communications system to meet the needs of economic growth. The investment is small and progress fast.[125]

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[124] Both the Chinese embassy in Washington, and the officials interviewed in Beijing, were willing to suggest a time for a new RFP. Both sources suggested spring 1986, but there was no evidence of the RFP by the beginning of summer.

The "buy and make" instead of "rent" decision may have been the practical consequence of the development of carrier rockets. The decision was also probably influenced by the long range view that a substantial number of communications satellites would be needed in China, and it would be better to start learning the technology at the outset. By 1979, at least, a decision had been taken to speed the process and take a quantum step in acquiring capacity by importing advanced satellites, and, along with them, as much technology as the foreigners would release and China could absorb.

In 1979 the Chinese Academy of Sciences raised the hopes of U.S. suppliers by stating, in an agreement with NASA, that China intended to purchase a U.S. broadcast satellite system "under suitable conditions." In 1980, the large-scale Chinese "economic readjustment" established conditions which the Chinese deemed unsuitable, and the project was shelved.[126] In 1984, the project was revived and a request for proposals issued. In 1985, the project was again "postponed," this time after proposals had already been received.[127]

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[125] FBIS, 3/16/84.

[126] The best description of this early bid situation is in Karen Berney, "An Aborted Launch," CBR March-April 1981.

So why this Chinese paralysis when it comes to selecting a satellite technology the country badly needs?

Is it a foreign exchange problem? Foreign exchange is always a part of the problem because China has so much to buy and so little to buy it with. The "we are a poor country" argument is put forth by the Chinese as a bargaining element in every important technology purchase. It has a certain validity in this case, as in the others. The Chief Engineer of the Ministry of Astronautics told the study team that, if China were a rich country like the United States, China could afford to buy both (C-Band and K-Band) satellite systems. But, he continued, since China can only afford to buy one system, it is necessary to be absolutely sure it is the right one.[128] It would not do to argue the point with the Chief Engineer. Nevertheless, the fact remains that the necessary funds had been budgeted, and a system appropriate for China already selected at the time the RFP was issued in 1984. Then doubts began to arise among decision makers concerning the clear superiority of the Ku-band (specified in the RFP) over C-band as the needed addition to China's existing communications system. The doubts were reinforced by technical advice from "China's friends" in the U.S.[129] The subsequent "suspension" of the RFP was not, apparently, so much a problem of sudden poverty as it was the result of a deep-rooted technical disagreement.

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[127] AFP, July 30, 1985. Hong Kong Standard.

[128] Chen Shouchen, February 25 interview.

There was plenty of room for a difference to develop over the appropriateness of the technical qualities of the two different systems. The technical section describes the technical qualities of both. For the Chinese it seemingly boiled down to a question of whether China should import the newer, higher frequency technology (Ku-band), and with it the technology that would permit China, at some later stage, to become a producer at this more-advanced level. Or should China import a less advanced technology (C-band), but one which is more thoroughly tested, is part of China's experience, and would adapt more readily to China's existing system. At least one supplier (GE) detected bureaucratic infighting over the question during the earliest period of consideration in 1979.[130]

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[129] The reference to "friends" was made by SSTC Satellite Office Director, Wu Jiaxiang.

[130] Karen Berney, "An Aborted Launch," CBR, March- April 1981. It appears that infighting over technology selection was joined with the bureaucratic struggle for control over the satellite circuits. Although the struggle for control undoubtedly continues behind the scenes, the important thing for the foreigner to know is who has come out on top, and thus who has to be dealt with. Our answer is above in "Principal Agencies."

Advocates of Ku-band could argue that more power in space permits the rapid spread of economically-produced small receivers on the ground. C-band advocates, on the other hand, could argue that even though C-band requires bigger and more expensive receivers on the ground, they are receivers that China already produces. In any case, the victory of the C-band advocates is a victory for pragmatism and a mature technology with which the Chinese are more familiar and more comfortable. It is a technology which may well provide improved satellite communications in a shorter time. The choice is evidence that the Chinese do not always want the latest and highest technology. They want a market-accepted technology.

Abrupt "postponement" of the 1984 RFP, caused China to lose face before the international supplier community with some resultant bureaucratic readjustment. The RFP was issued through the China Broadcast Satellite Corporation and put the CBSC out on a limb[131] for a Ku-band direct broadcast satellite. With European and American proposals already in hand, the internal differences over the proper technology that led to the RFP "suspension" was a public blow to CBSC prestige. Since the CBSC officers could hardly make a public retraction of their Ku-band advocacy, a new request for foreign proposals would require a new CBSC. That we have. But, before the foreign supplier goes to considerable trouble and expense to prepare another elaborate proposal in response to the expected RFP, how is he going to know that the new RFP is a fully approved RFP which is guaranteed against postponement? He isn't. That, unfortunately, is just one of the hazards of doing business in China. It is entirely likely, however, that the eight-year battle over technologies has finally produced a clear winner, the C-band, and this time the CBSC will really mean it when it asks for proposals.

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[131] "China Eyes Satellite Bids," Management Information Systems Week, October 17, 1984.

7. Transfer Modes

If the Chinese have indeed chosen the satellite system they will import, the matter now turns to how, and how much, technology transfer will be attached to the purchase. It will be one of China's most significant modernizing transfers, and it will go a long way to covering the inadequacies of a communications system needed to support economic growth.

Ford Aerospace[132] expects that the second RFP[133] for satellites will reflect a Chinese insistence on transfer of technology which will enable China to become a producer of these satellites. There is a way the RFP could accommodate this, and yet still provide a commercially attractive proposition. Through a system supply contract, the Chinese can purchase two satellites abroad with access to the manufacturer's facilities during construction and testing. Then a third satellite could be produced in China, under license, with sufficient foreign engineering assistance to insure the quality of the finished product.

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[132] Bob Berry.

[133] The second RFP will be the third Chinese solicitation because the first was not subject to international bidding and consequently did not take the form of an RFP.

Chinese production of the third satellite would take place without the difficulties China has sometimes encountered in licensed production. The manufacturing technology for C-band satellites is well-established and assimilable. Multi-purpose C-band satellites have been produced in the U.S. for fifteen years, and in Europe for five years. A combination of buy two and make one would give the Chinese a chance to learn how to make satellites of higher quality, long life and greater efficiency. This type of gradual transfer fits the normal pattern of successful transfer used by China in other technologies such as the agreement for Chinese manufacture of Westinghouse generators.

The way the Chinese will actually go about developing the new RFP could be quite different than that just described. There is some supplier concern[134] that the new RFP will reflect a Chinese intoxication with their indigenous satellite successes. That, combined with a miscalculation about Chinese technical capabilities, could lead to an RFP calling for production in China of all three satellites with minimal foreign guidance. The import would consist of essential foreign components to be put together with China-made components.

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[134] Ford Aerospace.

An RFP which simply calls for foreigners to come to China to teach satellite making appears possible in view of statements made to the study team by Chinese officials. The possibility is also sustained by the fact that, after using COMSAT for technical support on the first RFP, and after seeking and then rejecting TDP funding for a feasibility study to support the upcoming RFP, the Chinese have decided to handle the new RFP completely on their own.

Ford Aerospace,[135] for one, says that, if the Chinese decide to start out making their own multi-purpose C-band under license, the company will walk away from the deal. Selling a few million dollars in assemblies, says the supplier, and then being asked to work with the Chinese on a Chinese satellite, doesn't make sense and wouldn't make money. There would be no incentive to negotiate a significant technology transfer. Other foreign suppliers might well feel the same way. An RFP which turned off foreign suppliers could mean more controversy and more delay for China's satellite program.

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[135] Bob Berry, Director.

6. Non-commercial transfer modes

Aside from transfers through straight commercial transactions (direct sale, licensing, joint ventures, engineering contracts and countertrade) significant transfers of satellite technology to China are possible in non-commercial modes. Foremost of these has been the obtaining of technology through search of the technical literature, including data bases.[136] Given the paucity of commercial activity, much of China's "self-developed" satellite technology can be attributed to this source. The Chinese acknowledged as much to a U.S. expert delegation.[137] They told NASA that they were particularly indebted to NASA manuals on the space program.[138]

We have already noted that Chinese officials credit much of their satellite progress to veteran technicians, some of whom received pre-revolutionary technical training in the U.S. The study team asked a ranking telecommunications ministry official[139] how many of the thousands of Chinese students going abroad were in telecommunications studies and would return to assist technical development of China's system. He was unable to give a number. He said that the system for choosing state-supported students was complex. He expressed a hope that operating ministries would obtain a larger voice in sending students abroad and reclaiming them upon their return to China.

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[136] The U.S. is just getting around to an effort to try to limit foreign access to U.S. government and commercial computer data bases which contain high-tech information. The problem is discussed in an article front-paged in the Washington Post, May 27, 1986.

[137] People to people delegation report.

[138] Interview with Peter Smith, NASA, February 12, 1986.

[139] Interview with Yun Jin, Deputy Director, Dept. of Science & Technology, February 22, 1986.

Technical seminars by foreigners traveling to China have been, since China's "opening" in the late 70s, a method much used by China to preview available foreign technologies. Many members of the National Council, who have become established China traders, were introduced to China through technical seminar delegations. (Interested companies are asked to submit a precis of the technology they were prepared to discuss before they are approved for an official invitation.) Leading U.S. aerospace companies have conducted numerous technical seminars in China on the range of their capabilities in satellite communications. Ford Aerospace, RCA, Hughes, and GE were each required to conduct two-week technical seminars, in Beijing in connection with the postponed 1980 satellite procurement.[140] It is not possible to quantify the extent of technology transfer which occurs through technical seminars, but the competitive situation, plus extensive

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[140] Karen Berney, "An Aborted Launch," BJR, March-April, 1986.

Q and A periods, invokes detailed explanations and has been used to advantage by technology-hungry Chinese technicians.[141]

Government to government technical exchanges give the Chinese an opportunity to fill technical gaps through a negotiated pattern of graduated exchanges. Although China has telecommunications technical exchange agreements with other governments (see below), an agreement with the U.S. was only signed in May of this year.

China exhibitions with accompanying technical seminars establish a competitive situation in which U.S. aerospace companies have found it necessary to be well represented in China. At the conclusion of the most recent exhibition in May, 1986, the Chinese aviation minister said the exhibition was particularly valuable because it "opened a window on modern U.S. aerospace products."[142] The significance of exhibitions for technology transfer is illustrated by the observation of a U.S. attendee that: "Many Chinese visitors interested in space had extremely specific subsystem questions, as if the answers to these questions would fulfill a specific Chinese technical information objective."[143]

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[141] A study team member has accompanied a number of U.S. technical seminar delegations to China.

[142] Editorial, "China's Technology Leap," AWST, May 26, 1986.

[143] Space Hardware Companies Probe Chinese Market," AWST, May 26, 1986.

In the eyes of some foreign suppliers,[144] extensive Chinese foot-dragging on technology import decisions is a calculated form of technology transfer. The lengthy Chinese indecision on the satellite import is cited as an example. However, we have found nothing to suggest that, as a deliberate tactic, the Chinese extend negotiations for a needed technology in order to create an opportunity to access and transfer portions of the technology. Whatever the cause for delay--financial caution, unfamiliarity with the technology, or differences over the appropriateness of the technology--delay is endemic in the Chinese system when it comes to large-scale technology import decisions. Foreign suppliers have been waiting for years for Chinese decisions on such things as: coal transport (unit trains instead of slurry pipelines, or both): nuclear power (ten imported plants or one); the Three Gorges Dam (one huge hydropower project or many smaller ones).

Even if not deliberate, a there is no question but that the extended period leading up to contract provides the Chinese with an opportunity to learn more about what the foreign supplier is doing and how he is doing it. It is a period available to the Chinese to sharpen their critical faculties for the final technology selection.

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[144] RCA/OTA interview, December, 1985.

For nearly ten years now (summer, 1986), in relation to the satellite procurement, the Chinese have not only been receiving delegations of foreign aerospace companies, but what is more important, the Chinese have sent numerous Chinese technical delegations to tour the installations of potential satellite suppliers in the U.S. and Europe. As part of the standard pattern for such technical delegations, the Chinese technicians sketch and note throughout the tours and presentations. In the evening, the Chinese delegation leader assembles the group for an exchange of views on the observations of the day. At a minimum, the observations uncover both the foreign state-of-the-art and corroborative evidence to support the direction of China's own activities.[145]

Obviously, the longer the pre-purchase period lasts, the longer the Chinese have to play off competing suppliers against each other while progressively enlarging the scope of the technology each is asked to transfer. At the same time, the Chinese are pressing ahead with their indigenous technological achievements. The launching of the two home-grown Chinese communications satellites, for instance, strengthens the Chinese hand, and raises the ante on the technology the foreigners will feel obligated to bid. Opinions differ as to the amount of technology the Chinese actually transferred to their own use during the satellite purchase delay. Officers of one involved U.S. supplier think the Chinese might have picked up enough technological information to go it alone with the first satellite.[146]

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[145] Study team members have accompanied six Chinese technical delegations on visits to U.S. companies.

The Chinese can argue that the longer they delay a satellite technology purchase decision, the better they know what they want, and the more likely they are to get it. This, of course, begs the question of how long the Chinese can afford to put off the establishment of a communications system which will meet China's minimum needs and will no longer threaten to stunt economic growth.

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[146] RCA/OTA interview.

D. INTERNATIONAL COMPETITION

--The United States, with its long experience and developed technical capability, is best qualified to supply China's need for satellite communications technology imports. What is the U.S. market position versus U.S. competitors? What looks promising, and where are the problems?--

1. The Market

Although substantial sales have been made by foreign suppliers, the China market for satellite technology sales has been somewhat restricted by China's concentration in engineering and building its own rudimentary communication satellite system. Furthermore, sales in related technologies are difficult to trace because equipment, such as the 1985 U. S. sale to China of some $200 million in computers, was not exclusively for satellite communications use. The attached "Satellite communications transfers to the PRC" lists satellite technology sales of some $60 million in the two years to mid 1986.[147]

The market outlook for satellite technology sales is promising. China has emerged as a space power and, after an auspicious start, space and satellite communications have potential as a growth industry in China, just as in the U.S., the USSR, Europe and Japan. As indicated in the foregoing, China recognizes telecommunications as a key development sector, and accepts satellite communications as a most important element in network development. China has invested heavily in developing a satellite capability,[148] and the current (7th) Five Year Plan calls for completion of a domestic satellite system. Foreigners, especially Europeans, have agreed to cooperate in China's satellite development, and Chinese delegations are abroad looking for customers for an expanded Chinese launch program.

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[147] Includes a data processing center valued at $10 million to be supplied by Matra (Fr.). The PRC has specified Digital Equipment Corp. VAX computers.

Despite the lag in the satellite systems sale, and the growing Chinese capability to produce related hardware, there will be many other sales opportunities. If not the satellites themselves, there will be a need for modern satellite components which China cannot duplicate. Gaps in the Chinese technological support infra-structure will have to be closed with technology transfers. The whole of the Chinese ground support system will require equipment in a number of allied fields, including computers. There are possibilities of joint ventures with foreign aerospace companies, not just in equipment, but in satellite services as well.

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[148] According to one Chinese official, in 1984 the PRC was spending almost 1 percent of its GNP on space research and development, equivalent to several billion dollars a year. "China in Space," Bradley Hahn, China Business Review, July-August, 1984

2. Competing countries

a) The Europeans

For foreign competitors in the sale of communications equipment to China, the big ticket item has been, ever since 1979, the expected sale of a satellite communications system. The sale, besides its immediate value of up to $200 million, would establish a technological connection of promising future value. The French and the Germans, have pressed hard for this sale along with the U.S.

During the protracted competition for supply of the satellite, the European suppliers, particularly the Germans, have expressed increasing willingness to permit Chinese engineers to have access to their factories during production of any satellites they might buy.[149] It is unlikely that any government would put restrictions on direct transfer of widely-used C-band technology, but Chinese access to production know-how will be a matter of supplier discretion and subject to the pressures of competition.

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[149] The Europeans have been seeking a close technological connection through cooperation agreements. Germany (MBB) has a reported agreement with China to jointly develop and manufacture equipment and components for telecommunications satellites. In 1984, MBB invited four Chinese engineers to assist in assembly of a satellite. Between 1975 and 1984 MBB received thirty Chinese delegations. Aerospace Daily, March 13, 1984, details the German cooperation agreement.

The UK, also, has an agreement with China for joint space projects. See C.S. Monitor, March 22, 1985, for details.

The Europeans will provide stiff competition for the U.S. in the expected satellite system sale. China's first foreign satellite purchase will be regarded as an important point of entry into the promising China space market.[150] For major sales like this one, Europe has generally been able to offer friendlier financing[151] than the U.S., but lowering of U.S. EXIM interest rates in 1986 will aid U.S. suppliers. When it comes to export licensing, the Chinese say they expect to get from Europe both faster service and a higher level of licensable technology[152] than that which they expect from the U.S.

The Germans and the French together have attempted to impress the Chinese with their satellite technology through joint tests of the PRC ground stations using the "Symphonie" satellite. The Italians have done likewise with their "Sirius" satellite.[153] The Europeans' continuing interest in joint space programs with China could be expected to grow in proportion to disinterest on the part of NASA or the U.S. private sector.

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[150] Ford Aerospace and GE in study team interviews. Where licensing is discretionary, the Europeans are likely to have a broader view.

[151] Early in 1986 the UK authorized a 300 million pound developmental credit for China at 5% for 20 years. (Financial Times, May 2, 1986)

[152] As indicated in the following, because U.S. licensing is stricter and takes longer.

[153] SUN Jiadong, "China Enters Era of Space Technology," JPRS, February 5, 1985.

Aside from satellite systems as a whole, the Europeans have been competing with the U.S. on system components. China has been considered a reasonable market for foreign supplies of C-band earth stations because, despite improving Chinese production, the foreigners can build and sell at prices which compete favorably with Chinese-produced stations, and are generally better quality.[154]

A recent Chinese announcement appears to close this market to outsiders, but a Chinese Embassy spokesman maintains that the announcement is simply an official certification that Chinese quality is now equal to that of the imports.

For the 1984 response to China's RFP, Ford Aerospace felt it wise to associate with the Europeans in a satellite bid to China. The company had observed that China likes to spread purchases around among foreigners for political purposes. Consequently, the U.S. company set aside its overall technical capabilities in order to participate in a consortium headed by a German company and including a French company, which submitted a joint bid. The joint bid may well have been the one most favored by the Chinese in the now defunct RFP, but Ford is prepared to go it alone on the second RFP, whenever it is issued.[155]

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[154] As indicated in the attached list of transactions, Canada's SPAR Aerospace Ltd. has sold nearly $20 million in earth stations.

b) The Japanese

Japan's continuing overall predominance in China trade is the result of a trade policy designed to keep Japan on top in a market which is of vital importance to the Japanese. Fortunately for non-Japanese foreign suppliers, satellite technology is one of the areas of Chinese imports where U.S. technology, and then European technology, is still superior.

But the Japanese have a space and satellite communications program which is advancing rapidly. Given Japanese dedication, marketing skills, technical capability, and proximity to China, it is to be expected that, in a very few years, the Japanese will be a major competitor to both the U.S. and Europe in China's aerospace development.[156] Yet the Japanese have shown a singular unwillingness to transfer technology to China, and the Chinese have criticized the Japanese for hanging back.[157] Perhaps the Japanese experience with their other neighbors, South Korea and

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[155] Bureau of National Affairs, August 15, 1984.

[156] "Japan Challenging Western Leadership in Space," AWST, July 14, 1986. In 1980 the Japanese won a $9.1 million contract to building the Beijing number three ground station link with INTELSAT.

[157] China Business Review, January-February, 1986.

Taiwan, have made the Japanese cautious about assisting the development of competing technological production. At any rate the Chinese have ranked countries by percentage of technical sales in the overall value of their China contracts. The UK and France lead with 80 percent. The U.S. is next with 72 percent. West Germany has 52 percent. Japan is listed for only 6.2 percent.[158]

U.S.-Japanese aerospace companies have recently been forming on China's doorstep. The combinations so far developed are Hughes with MITSUI, Ford Aerospace with Mitsubishi and RAC with Sony. All three Japanese companies are interested in satellite production. Sales to China might seem a reasonable prospect for these joint companies, but the Chinese have made clear on many occasions that they prefer to deal with U.S. companies directly.

3. U.S. marketing advantages

In the distant and difficult China market, U.S. suppliers of technology are fortunate to have some things going for them that are not generally available to them in other foreign markets. For one thing, there is the oft-stated Chinese preference for U.S. technologies. For another, there is the unique array of government-to-government agreements for U.S. programs in China. Some programs directly facilitate U.S. business activities, while others pave the way for follow-up by familiarizing the Chinese with U.S. technologies.

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[158] China Business Review, May-June, 1985.

a) Acknowledged U.S. technological leadership

The study team was told by every Chinese official we met that the U.S. is the world leader in space technology including, of course, satellite communications.[159] The Chinese are keenly aware that, at least in this technical area, while other countries can offer technologies which are almost equivalent and sometimes better priced, the U.S. has the most experience, the widest variety of product, and the most highly-developed technical support infrastructure.[160]

b) Market awareness

Because the U.S. was later in establishing relations than competing countries, U.S. firms were relatively slow getting established in China. Nevertheless, seasoned U.S. exporting companies, aware of the market potential, have been making up for lost time. They realize the importance of maintaining a presence in China, because the Chinese want to deal with "old friends" who are with China for the long haul. Major U.S. aerospace companies, are now represented in Beijing. Most are there for other than satellite business, but all of the qualified companies are carefully monitoring the emerging China communication satellite situation. The fact that China's satellite telecommunications program is under central control in Beijing works to U.S. advantage. Few of the U.S. companies which are prepared to sell in China's space market have sold enough in China yet to justify a large and expensive China office, and an extensive sales effort. Even if the European competition, and certainly the Japanese competition, were willing to do so, the U.S. companies would be unwilling to travel around China chasing potential end users. Sales contact with the few key officials in Beijing, plus participation in the occasional exhibition, makes sense in terms of keeping in touch while the market develops.

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[159] The loss of the space shuttle was never mentioned by the Chinese during our February 1986 visit. This was probably not so much out of deference to our feelings as it was Chinese recognition and acceptance of the hazards of space programs.

[160] Jing Zhaopian, PRC Embassy First Secretary to the study team.

c) Willingness to invest

Second only to the Hong Kong Chinese companies, U.S. companies have demonstrated a readiness to move into the marketplace and participate in cooperative arrangements and joint ventures in China. The Hong Kong businessmen are mostly in small joint ventures with 80% of the total registered investment. The U.S. has 7%, and Japan is third with 6%.[161] Although space communications are not yet included among U.S.-China joint ventures, U.S. aerospace companies like Boeing and McDonnell-Douglas are actively involved. U.S. company willingness to accept joint management responsibilities, and to share risks[162] with Chinese socialist managers is a positive indication of U.S. willingness to do long-term business in China. U.S. readiness to work with Chinese managers is not so widely shared by the Japanese, who have a market position with a value several times our own. This suggests that, as long as the Japanese can sell to the China market without such a drastic step, the Japanese prefer not to dilute their management authority in joint ventures with the Chinese.

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[161] Far Eastern Economic Review, March 20, 1986.

The decline in the value of the dollar reverses a trend which has been working against U.S. trade with China, particularly against competition backed by the undervalued Japanese yen. The decline in the dollar will be particularly helpful in technology trade where, the higher the technology, the higher the percentage of price attributable to the inflating costs of U.S. R&D.

d) Chinese students

It has been observed that: "Technology is not neutral, but comes in a given socio-economic-cultural-political package. It is linked to a given economic base."[163] Chinese students abroad are a conduit for the transfer of technological influence to China. The U.S. has received more than one-third of all the Chinese who have been sent abroad to study the technologies of the developed countries since the opening to the outside world in the late 70s. In 1986, fifteen thousand advanced Chinese students (9,000 government sponsored) are being educated in the U.S. and learning about technologies which could be applied in China tomorrow. Although the student training is not aimed directly at obtaining U.S. commercial advantage, technology preferences are being ingrained in a way that will eventually serve the U.S.-China commercial relationship.

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[162] The U.S. and China have had problems in agreeing on an investment treaty but OPIC insurance is available for U.S. investment in China, and OPIC has been active in China investment promotion. A double-tax convention was ratified 96 to 1 on July 23, 1986, in the Senate. (China Daily July 25, 1986)

e) U.S. agency support

The Chinese have difficulty understanding the division between U.S. government and U.S. business in foreign activities. They have observed the close relationship between government and business which prevails with other country programs in China, particularly with the Japanese. They expect that, similarly, government and business would work together on U.S. programs in China. They seem gratified and reassured when this appears to be the case. Fortunately, because of the large number of U.S. agency programs in China, the possibility of collaborative U.S. business-government activity may, in fact, be wider in China than in any other country.

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[163] "Assessing Technology," Neville D. Jayaweera, Development: Seeds of Change, 1985:1

The large number of U.S. agency programs indicates the extent of U.S. official interest in Chinese development. Even those U.S./China S&T exchange programs, which are more science than technology, provide indirect support to U.S. business through the availability of accumulated knowledge, useful in marketing, about the progress the Chinese are making in a particular development area.

The U.S. has no aid program for Communist China. Japan, and the other Western nations, do have aid programs. The lack of U.S. aid dollar support makes these other U.S. agency programs all the more important for support of business. The programs provide resources capable of supporting a broader program of U.S. technology sales of satellite communications to China. To take advantage of them, businessmen must moderate their inbred antipathy to working with government, and overcome their unfamiliarity with U.S. agency program. Both are possible.

i. Trade and Development Program (TDP)

TDP, separately budgeted, but considered by Congress along with the AID program, provides financial support for project identification and feasibility studies for Chinese priority projects which promise a value multiple in U.S. exports. China has become a major focus of the multi-million dollar TDP program. On the presumption that U.S. aerospace companies had a good chance to win a satellite export contract, TDP offered to fund a $200,000 feasibility study of satellite communications systems for China. Even though, after considerable negotiation, the study proposal was finally dropped by the Chinese, the U.S. had at least demonstrated to Chinese officials its willingness to support feasibility studies for U.S./China aerospace development. Such studies could be important as the U.S. presses ahead with space communications programs in China.

ii. COMSAT

As an indication of Chinese faith in the U.S. agency's independent technical judgment, the Chinese asked the U.S. representative to INTELSAT to provide technical assistance in preparation of the 1984 request for proposals to supply a satellite system. Subsequent to the Chinese withdrawal of the RFP, COMSAT made an abortive attempt to sell China two satellites COMSAT had ordered, but which COMSAT decided not to program.[164] With its interest in satellite sales set aside (the satellites were sold elsewhere), COMSAT is in a position to offer significant support to U.S. participation in satellite programs in China, particularly in the area of systems design. As pointed out below, COMSAT can also offer to Chinese technicians COMSAT courses in satellite management in COMSAT facilities.

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[164] COMSAT was offering fully-manufactured direct broadcast Ku-band satellites, while the Chinese were interested in technology transfer through participation in the assembly of C-band satellites. COMSAT's two satellites have since been sold to a U.S. company for TV broadcasting in the U.S.

iii. Science and Technology Protocol

After three years of negotiation[165] the signing, in May 1986, of the protocol for U.S.-China cooperation in telecommunications science and technology, should be one of the most important agreements in the growing technological relationship of the two countries. Among other things, it provides a basic instrument for the promotion of U.S. private sector participation in China's telecommunications development.[166] The U.S. agency administering the agreement is significantly the National Telecommunications and Information Administration (NTIA), a part of the Department of

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[165] The protocol is the latest of 20 agreements negotiated under the 1978 umbrella agreement for S&T exchanges. The telecommunications agreement was held up at one point because of disagreement within the U.S. Government as to whether fiber optics were too sensitive a technology for exchanges with China. Fiber optics were eventually excluded, even though TDP identified several projects for U.S. participation. The Chinese have continued to develop fiber optics on their own, and in agreements with Italy and the Netherlands (Communications International, London, June 6, 1986). AT&T is also reported to be working with China on fiber optics.

[166] In 1984, Congressional hearings on the protocol, Representative Al Swift (D-Wash.) promoted the protocol as providing important telecommunication trade opportunities for U.S. companies. (Bureau of National Affairs, August 15, 1984.)

Commerce. The Chinese administering agency is the Ministry of Posts and Telecommunications.

As indicated earlier in this report, in the final version of the protocol the Chinese understandably omitted references to the need for U.S. help in telecommunications management and planning which appeared in earlier versions. Nevertheless, the Chinese officials, who came to the U.S. for the signing, assured NTIA that, although no longer specified in the protocol, management and planning recommendations are welcomed. The Chinese officials suggested the recommendations be included in the China study to be conducted by the mixed U.S. Government-private sector expert delegation which is a principal feature of the protocol.

The U.S. expert delegation, divided into several sections, will include a satellite communications company, plus at least seven other U.S. telecommunications companies, and three or four government reps. They will be in China for three weeks in the fall of 1986. The U.S. experts are invited to study the status of China's civil telecommunications industry, including facilities operations and scientific and technological development.

Providing it is made up of technicians, and not marketing managers, the U.S. delegation will be in a position to gain commercially valuable insights into the state of China's telecommunications technology and her technical import requirements. Traveling under the right auspices, it will be able to access many more important officials and much more market information than would be possible under normal circumstances. A Chinese return delegation of ranking telecommunications officials is to come to the U.S. in the first half of 1987 to examine the production and operation of American civil communications. In addition, the Chinese will be attempting to work out details of bilateral cooperation in telecommunications technology and application of communication systems. One of the listed individual technical exchanges calls for the U.S. to send an expert to lecture on satellite communications.

An extensive protocol annex is designed to ease concerns and head off disagreements about the handling of confidential information developed or exchanged under the protocol. The provisions are necessary to stimulate a frank technical exchange, and grow out of U.S. experience with previous protocols. Exchanges under the long-awaited protocol will be important to the creation of a setting for enhanced satellite communications technology transfer. But it is essential that the U.S. take early and full advantage of the opportunities presented. Competing countries will be signing similar protocols with China, if they have not already done so.[167]

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[167] Direct assistance for U.S. business is provided as well under the Department of Commerce, January, 1984, Industrial Cooperation Accord with China. Under the accord, the U.S. is to provide private sector technology to support the PRC's priority program for technical renovation of existing companies.

iv. A NASA Exchange?

The S&T exchange agreement of the greatest significance for cooperation to enhance U.S. participation in China's space and space communications program would be an agreement between the Ministry of Astronautics and NASA. Without an exchange agreement which involves the world's premier space agency, U.S. Government support for a wider U.S. role in China's space development will lack validity.

For its part, NASA has not been very interested in the proposed S&T exchange with the Chinese.[168] In 1981, when negotiations started, China had agreed to consider purchase of several satellites and related equipment from the U.S. When this did not materialize, NASA's interest in technical exchanges slackened. Throughout the protracted negotiations, NASA has felt that the Chinese were asking for a lot and offering very little in exchange. NASA says the project is now on the "back burner" until the agency can complete the readjustment necessitated by the shuttle disaster. Also necessarily on hold is the NASA project to include a Chinese payload specialist on a future shuttle flight.

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[168] Peter Smith, NASA's Chief, International Political Programs, has been one of the principals in the negotiations with MOA.

For their part, the Chinese have been frank in expressing their disappointment at slow progress on what they consider to be a most important exchange in a high tech area where they have demonstrated outstanding capabilities. They have implied that NASA's reluctance demonstrates official U.S. unwillingness to engage in technology transfer arrangements related to space. Dragging the problem out into the open at a space conference in Italy in 1985, Yang Jiachi, MOA Chief Engineer, addressing the conferees, said: "We are willing to cooperate with all countries in the field of space, but we place special emphasis on cooperative relations with European countries and hope to make it more substantial. In 1981 we began to explore cooperation with NASA. But it was only in 1984 that a preliminary agreement between the two sides was reached on five joint science projects."[169] Updating the Chinese disappointment, Wu Jiaxiang, Director of the Satellite Office, SSTC, told the study team in Beijing in May, 1986, that China has done all possible to get an exchange going, and that it was up to NASA to close in on an agreement.

It appears to the study team that it might be worthwhile for NASA to at least take another look at the proposed protocol with the Ministry of Astronautics.[170] NASA might even consider a broader exchange than the limited space science exchange now contemplated. Whatever NASA's future role, whether as a commercial or a technical agency, NASA's participation in exchanges with China would signify full U.S. Government support for U.S. involvement in China's growing space program. It would also provide an additional vantage point from which trained observers could monitor the Chinese efforts.

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[169] AWST, April 8, 1985.

[170] Failure of the U.S. to respond to Chinese overtures leaves room for others who see strategic as well as commercial possibilities in space cooperation with China. As reported in the

v. Telecommunications Training Institute

The United States Telecommunications Training Institute (USTTI)[171] is a facility, which has been principally developed by the U.S. private sector, and is available to support training which will facilitate technology transfer from the U.S. The institute was founded as a result of the efforts of a U.S. private/public delegation to the 1982 International Telecommunications Union Conference. At the conference, the delegation discovered a compelling unmet need in developing countries for more hands-on and managerial training in telecommunications. The institute course (several months in duration) are presented in the training facilities, laboratories

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U.S. press (Wall Street Journal, July 29, 1986), Gorbachev's Vladivostok speech, after offering concessions on "three major obstacles" China has cited in relation to improved relations, also suggested the possibility of joint space exploration and the training of Chinese cosmonauts in the U.S.S.R.

[171] Information on USTTI from Raymond B. Crowell, Senior Director International Planning and Liaison, COMSAT.

and factories of a dozen major U.S. telecommunications companies. Pertinent courses are: Satellite Communications Management (COMSAT), SCPC Satellite Systems for Rural Communications (M/A Comm), and Satellite Systems Applications for Rural Communications (AID Rural Satellite Programs). USTTI supplies "training that will hopefully insure that people in all corners of the developing world have an opportunity to participate in the technological benefits we enjoy in the United States."[172] As a practical matter, the more the developing countries advance technologically the better customers they become for advanced U.S. telecommunications technology. Training in U.S. company facilities permits identification of the needed U.S. technologies by the Chinese technician who may eventually use them.

To date, the PRC has remained generally unaware of the potential of USTTI to provide for many of their technical training needs. Yun Jun, Deputy Director of Science and Technology for the telecommunications ministry, who was interviewed by the study team in Beijing, and who led the Chinese delegation for the signing of the telecommunications protocol, did not know about USTTI. Of the 500 graduates of USTTI, only two (both within the last year) were from China. USTTI training at U.S. companies will be available to Chinese communications technicians as a follow-up to the U.S. delegation's study of the status of China's terrestrial and satellite communications under the telecommunications exchange protocol.

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[172] From the USTTI 1986 Annual Report.

vi. EXIM

The U.S. Export-Import Bank has previously been known in the China trade for its low profile and high interest rates. The dramatic 1986 change in the U.S. interest rate situation is leading to a change in the previous image of EXIM. Since the early 1980s, the EXIM interest rates offered to China have declined gradually from a high of over 10 percent to a new low of 7.4 percent for the second half of 1986. The new rate, lower than World Bank rates and the lowest allowed by OECD, can put EXIM back in the picture in an area where Japan and the Europeans, with large and comparatively low interest development credits, have been dominant. EXIM has let it be known that EXIM is willing to provide follow-on financing for U.S. technology suppliers taking advantage of opportunities provided by TDP-funded feasibility studies for China projects. EXIM has chalked up outstanding offers to China of $200 million to date. With the new rate, the bank expects up to $300 million in export credit requests during the third quarter of 1986. The Chinese will be pleasantly surprised at the new evidence of U.S. Government agency willingness to support technology transfer.[173] U.S. aerospace companies which have made frequent use of EXIM credits in other parts of the developing world, can now look forward to their possible use in China.

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[173] Based on a report in China Market Intelligence, National Council, August, 1986.

4. Some U.S. marketing problems

a) Discouraged companies

U.S. companies competing for China's proposed purchase of satellites have spent very large sums of money, and devoted much company time, to pursue, what promised to be, both a very substantial sale, and a chance to establish a firm lodgment in a very promising market.[174] When the initial sale possibility evaporated, and then, several years later, the revised Chinese satellite purchase proposal was "postponed", these companies experienced a good deal of executive disenchantment with the China market. Lack of enthusiasm for satellite communications sales would be understandable.

The satellite postponement scenario, unfortunately, is typical of a number of other prominent China scenarios which feature the same kind of heavy investment of the foreign suppliers time and money up front followed by long delay and possible eventual disappointment, or perhaps questionable achievement.

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[174] Hughes was estimated to have spent $500,000 on the 1979-80 projected sale alone. Ge expenditures were estimated at $300,000. See Karen Berney, CBR, March-April, 1981.

U.S. executives who see long-range potential in China cannot be sure that controlling interests in their companies are not more easily discouraged, have less patience and persistence, than their competitors in the China market.

It is alleged by an experience non-U.S. trader in Hong Kong that American companies have been spoiled by the American market.[175] U.S. companies, he maintains, expect to return a profit within two or three quarters after the initiation of a venture in China. The critic insists that the only way to approach the China market is to be prepared for the long haul, with minimum profitability at the outset, while waiting for the market to grow. The approach suggested is not antithetical to that taken by a number of American companies involved in China. Yet American stockholders do want action, and there are many easier places to make money than China, so company management is hard put to defend long range opportunity against persistent Chinese inability to make big purchasing decisions. Fortunately, none of the firms involved in the satellite RFP are ready yet to call it quits. They are large firms with other business interests in China.

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[175] Traugott Goll, Jebsen and Company.

5. Export licensing - the biggest problem

a. U.S. national controls

To gain an impression of the relationship of U.S. controls to possible satellite communications sales, the study team held interviews with U.S. officials and U.S. firms concerning the effect of export licensing. The impression obtained is that, despite repeated, and partially successful efforts by U.S. officials to liberalize and expedite export approvals, the businessmen and even some of the bureaucrats, continue to feel that U.S. national controls put U.S. firms at a competitive disadvantage. Not surprisingly, the Pentagon, as the ultimate guardian of U.S. security interests, is held to be the principal barrier to export license approval.

A recent Pentagon ruling against equipment for networking of computers (a system potentially useful in satellite communications systems) has disappointed U.S. marketing companies in China. The companies say the Pentagon believes that tieing computers together multiplies their power. In fact, the Chinese generally under-use the computers they have. The companies insist that networks are only a device that saves the time of running a messenger between individual computers. They maintain that it will only be a short time before competing countries will sell the networking equipment to China.[176]

The State Department's Office of Munitions Control (OMC) is involved in satellite communications technology licensing. OMC initially screens export licenses for items on the Munitions List. The list includes satellites. OMC says it gets a great deal of pressure for advance approval of U.S. exports from both Chinese potential buyers and hopeful U.S. sellers. The office is at pains to explain to the Chinese that OMC reacts only to specific export requests from U.S. companies. OMC will not give U.S. firms a prejudgment before it has received a license request, otherwise, OMC says, the U.S. firms will be selling right up to the technology ceiling, and then asking that it be lifted. A ranking OMC official concedes that technology ceilings are constantly being raised, and that a good deal of the pressure is coming about as a result of liberalized licensing by competing countries.[177]

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[176] The American High Tech Forum including Honeywell, AT&T and GE.

[177] The OMC official, Steve Komanelis, is Special Assistant for Space, so he is talking to the problem of satellite technology licensing. He is faced with the twin pressures of U.S. supplies and European suppliers. European suppliers, taking advantage of more liberal national licensing policies and the informality of COCOM controls, export to China technologies which would not be licensed for U.S. export. Providing the U.S. suppliers can provide evidence of the competitive "end run," OMC is forced to follow the leader and license the same technology for U.S. export.

The China desk in Commerce could not document cases of U.S. companies having lost a sale to foreign competition as a result of the U.S. company's inability to come up with an export license while competitors were able to do so. The desk has heard (as did the study team) U.S. companies allege that this occurs. In the desk's view, it is more likely that the Chinese would cancel an order because U.S. licensing procedures simply take too long, and certainly longer than countries competing with the U.S. The Chinese could use this as the reason for backing out of a deal, even though the real reason could be that they had run out of money or simply changed their mind.

Some U.S. firms agree that U.S. licensing delays are the biggest problem. Robert McDonald, who heads Honeywell's China Office in Hong Kong, says that, after initial submission, applications are simply "nibbled to death" with revisions and questioning.

Jeff Lee, on the Commerce China desk, suggests that a U.S. exporter might seek an initial sale to maintain competitiveness and show some success in the China market. Having proceeded with the easily-licensed segment first, he would then, further down the line, run into licensing problems with more questionable segments.

Commerce officers concede that U.S. export licensing is slow and painful because of the huge size and complexity of the U.S.

bureaucracy. Many more approval agencies have become involved in the process here than in other countries. In Japan, for instance, MITI alone handles the whole process. U.S. Government officers also admit that bureaucratic attitudes cause temporizing. Each of the U.S. Government agencies concerned conscientiously examines the many U.S. license requests against its own agency definition of national interest. While the governments of competing countries are looking for a way to make the rules bend for exports, the U.S. Government is looking for ways to prevent the exporters from bending the rules.

Some U.S. companies complain that the system of ad hoc licensing results in approval or disapproval depending on whose desk in the Pentagon the request lands. They say that subjective decisions result in two technologies at the same technological level getting two different reactions from the licensing authorities -- one approval and one disapproval.[178]

A U.S. company describes a type of post-purchase export control on the flight control inertial guidance system for a Boeing 767 sold to China. No spares are allowed to be kept in China. If a unit fails, it is sent back to the supplier in return for a replacement. The apparent presumption behind this procedure is that the Chinese will not ground the plan long enough to study the system. Yet even a well-scheduled airplane spends enough time on the ground for Chinese "students" to become familiar with the system.[179]

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[178] Robert O. MacDonald, Director Business Development, People's Republic of China, Honeywell, Inc.

In the Chinese capital, the study team learned that the U.S. business community in Beijing was so exercised about loss of sales, as a result of over-zealous application of U.S. licensing controls, that they had organized a High Tech Forum which includes major U.S. telecommunications and aerospace companies. The team attended the first meeting in April, 1986, of this unusual voluntary association of U.S. company reps with a common cause. At the meeting, forum members were enjoined to provide the Embassy with hard evidence of loss of sales on products which were refused by the U.S., but licensed by competitors.[180] The problem with the Forum's approach is that even abundant evidence would indicate, after the fact, where U.S. controls were wrong without making them right. Meanwhile, the U.S. business community in Beijing was wrestling with another licensing problem -- how to operate under a new system of end-use certificates imposed by the Chinese in an effort to comply with U.S. and COCOM export regulations.[181]

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[179] Bob Berry, Director, *Ford Aerospace*.

[180] Two months after the meeting, the evidence had not reached Washington. Such evidence is hard to come by, and sometimes painful to submit.

[184] The system had just been disclosed at the time of the study team's visit to Beijing in February 1986. The U. S. Embassy was to seek clarification and simplification.

After obtaining hard-won approval from U.S. national licensing authorities, the would-be exporter faces another barrier, the multi-national scrutiny of his export license application by COCOM.

b) COCOM

The Coordinating Committee (COCOM) is an informal arrangement between governments which reviews applications from member countries (the industrialized democracies) for the licensing of technology for export to Communist countries. COCOM does what it was intended to do -- discourage the export to Bloc countries of technologies which could be used against Western interests. There is a body of opinion in the U.S. export community, however, which holds that COCOM overdoes what it does, and adds greatly to the difficulty of technology trade with China.

Reported here is a composite of the frequently-stated views of aggrieved U.S. businessmen and concerned bureaucrats who agree that COCOM erodes the U.S. market position in China because companies in competing countries are consistently able to use COCOM to obtain advantage over U.S. companies. A sampling of views:

- Since it requires unanimity, COCOM is a horsetrading organization which is used by its participants to get around licensing restraints. The approach is: "I'll approve your license, if you approve my license."[182]

- Whichever country is most conscientious about using referral to COCOM to resolve licensing doubts will suffer the largest commercial loss. That country is the U.S., and even U.S. officials acknowledge this.[183]

- The new COCOM system of broadening the discretionary authority of individual countries with post-hoc reporting, is a system of recording licensing abuses which have already occurred.

- Enlarging the degree of national discretionary authority on licensing submission to COCOM, enlarges the opportunity for competitors with the U.S. because they are habitually less discrete.

- Although COCOm attempts to establish technical parameters for impermissible exports, there are numerous ambiguities which can work against U.S. commercial interest.

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[182] Richard Abington, GE, Hong Kong.

[183] OMC's Koumanelis.

- COCOM diverts China trade into roundabout channels. For instance, Japanese exports to Singapore of items which are impermissible for export to China can then be reexported from Singapore to China.[184]

- National authorities of countries competing with the U.S. "cheat" by using less rigorous national export licensing procedures, and by not referring exports to COCOM.[185]

- The U.S. refers by far the largest number of cases to COCOM so the U.S. has the most to lose by protracted COCOM consideration which can run up to a year.

- It is better to submit a "laundry list" of related license requests (as the Europeans do) than individual, ad hoc requests (as the U.S. does).[186]

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[184] This, and the preceding three statements, were voiced at an OTA panel meeting in March, 1986.

[185] Richard Kask, GE.

[186] Dan Hoydysh, Office of Technology Policy and Analysis, Dept. of Commerce. Also the preceding statement.

6. Chinese perceptions of U.S. technology transfer

Chinese perceptions of the U.S. attitude toward assisting China's economic development have become a very important factor in shaping the pattern of U.S. - China relations. The study team found that the Chinese have broadly-shared, and strong views, about U.S. technology sales to China. In essence, the Chinese feel that the U.S., which has the most desirable technology, is not doing what it could and should to transfer that technology to China. Whatever its validity, the Chinese view persists, is repeated to all U.S. visitors, and clouds the U.S.-China relationship.

Aware of Chinese sensitivity on this score, in their 1985 visits to China both Vice President Bush and Commerce Secretary Malcolm Baldridge made explicit promises to speed the process of U.S. export license consideration. The significance of our self-imposed technology transfer limitations was underlined once again by the new U.S. Ambassador Winston Lord, who told the May 28, 1986 annual meeting of the National Council for U.S.-China Trade in Washington that the U.S. must continue to monitor its technology transfer policy to insure that sales of appropriate advanced technology to China are not hampered by U.S. Government restrictions.

E. IMPACT ON THE UNITED STATES

1) China, 1986

Ten years ago, 1976 was the year everything changed for China. The Cultural Revolution came to an end. Chou Enlai died. Mao died. The "Gang of Four" had tried to take over from the dying "Great Helmsman" who had steered so erratically. They were arrested by the gang-busting, twice-purged and rehabilitated, chain-smoking, septegenarian who set China's socialist development on a whole new course. The Deng Dynasty, China's second socialist dynasty, had begun. It was, as Deng himself acknowledged, the beginning of a "second revolution."

At the end of the first decade of the Deng Dynasty, it would appear that the paramount leader, now 81, has (fortunately for China's stability) lived long enough to set China firmly on the new course he has charted. Dengism in altering the basic nature of China's political and economic system, and reshaping its society.[187]

The Dengists have no hidden agenda. Their objective is clearly stated. They aim to make socialism work as the system which will modernize China. Internally, Dengism means development through economic reform together with decentralization, increasing use of market forces, and entrepreneurial incentives. Political reform--separating the party and the government--is next on the Deng agenda.

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[187] Modernizing China. Post-Mao REform & Development. Doak Barnett and Ralph N. Clough, Boulder, Colorado, Western Press, 1986

Externally, Dengism seeks infusions of modernizing technology through an opening to the outside world which has brought a rapid expansion of economic relations with the industrialized democracies. Thousands of Chinese students flock to the U.S. and other Western nations. China says it follows an "independent foreign policy of peace"[188] because it will be impossible to bridge the gap of "backwardness and poverty" between China and the developed countries "without decades or even a century of peaceful economic development." And because economic development and expansion of military strength are "mutually exclusive", China is deemphasizing its military by drastically cutting its forces, reducing military budgets, and converting military to civilian production.[189]

But China's history since the 1949 communist takeover has been one of abrupt policy changes accompanied by widespread economic and social disruption. So it is appropriate to question the stability of the Dengist leadership and its policies.

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[188] From General Secretary Hu Yaobang's address to the British Royal Institute, June 11, 1986

[189] While the Maoists believed war was inevitable, the Dengists declare that "the growth of the forces for peace in the world will outpace the growth of the forces for war." (Deng to the 3rd Plenary Session of the Central Advisory Committee, October 22, 1984 in FBIS, China, January 2, 1985.)

Deng is a very experienced and capable politician. He has directed a campaign of methodical "rectification" which has eliminated many of the "Gang of Four" adherents and cultural revolutionists ("left deviationists") in the party, the army, and the government. Dedicated younger Dengists have been installed in place of the deviationists. At the same time the leadership has acquired wide popular support through reform-induced improvement in the standard of living, especially in the countryside where 80 percent of the population live. A well-administered effort has been made to regain the support of intellectuals and technicians disaffected by the excesses of the Cultural Revolution.

It seems unlikely that there would be a change of leadership that could reverse the Dengist directions and lead China back towards the chaos from which it has come. In fact, opposition to Dengism appears to be centered, not on the Dengist reforms themselves, but on some of the characteristics of the reforms, and the speed with which they are being implemented. The leadership has responded to public concern about corruption spawned by the new economic freedoms, and has vigorously pursued an anti-corruption campaign. Deng has resolutely resisted the establishment of a Deng personality cult so that, after the old man goes, Dengism can survive without Deng.

And how does satellite communications fit into the picture of China in 1986? China's success in establishing a satellite communications system is outstanding evidence of the self-generated technological capability China can bring to bear on the problems of modernization. The highly-publicized occasion of the successful orbiting of China's second communications satellite was the occasion for national rejoicing and an outpouring of national pride. At the same time, the admitted limitations on China's technical capability to maintain the pace of satellite communications development is a demonstration of the importance of opening to the outside world for transfer of needed technology. Satellite communications promise to support and enhance the leadership's efforts to bring one quarter of the world population into the world community, and give China a chance, during the 21st century, "to join the ranks of the advanced nations."

2) The U.S.-China Relationship and U.S. interest

In preparation for the study, and in order to establish a framework for the examination of satellite technology transfer to China, the study team interviewed key individuals in U.S. agencies involved in the development of U.S. China policy, particularly U.S. economic policy (list attached). There was general agreement as to what U.S. policy is. There was also unanimity of opinion on the importance of technology transfer to the maintenance and development of U.S. policy.

Since U.S. recognition of China in 1978, the China policy that has emerged has enjoyed strong bi-partisan support. The U.S. recognizes the People's Republic as a friendly, non-allied country. Our policy is to keep China secure, independent, peaceful and developing. Achievement of this goal is fundamental to the success of overall U.S. policy in Asia and the Pacific. Policy implementation is based on a convergence of interests, including shared strategic objectives and mutually advantageous economic cooperation. Perceived benefits have been such that the two sides have put aside differences over Taiwan and alleged U.S. protectionism while continuing to develop their relationship.

Strategically, the U.S. and China have a current common interest in opposing Soviet expansionism in the Pacific. In support of this convergent interest, the U.S. is assisting China's conventional military development with defensive weapons and related equipment. In return the Chinese provide the U.S. with technical windows on the Soviet Union and facilities which are beyond the purview of this report. But the military/strategic relationship is limited. While China is deemphasizing the military and following an "independent foreign policy of peace," it would not want to alarm the Russians. The U.S., furthermore, does not want to support a military buildup on one side of the Taiwan Straits.

On the other hand, U.S. participation in China's economic development provides unlimited opportunity for strengthening the interrelationship of the two countries. Other countries, particularly the other industrialized democracies, are competing in the China market. China's near neighbor, Japan, has a trade with China almost two and one-half times our own. And Hong Kong, on China's doorstep, nearly doubles our trade level. But the U.S., as number three, has a China trade of better than $8 billion, with U.S. exports increasing at 27 percent in 1985, and with U.S. machinery and transport equipment (the principal export at nearly $2 billion) more than doubling in value between 1984 and 1985. Furthermore, as indicated in the foregoing, China has stated a preference for U.S. technology, particularly in areas of critical importance to Chinese development--energy, transportation and communications. In these areas, U.S. suppliers have a very large potential market in the expanding China economy.

Along with other modernizing technologies, China has extensive need for transfer of U.S. satellite communications technologies. At the same time, the suppliers of that technology do not fear possible Chinese competition as a result of the transfer of that technology. China's emergence as a space power, including her success in the satellite area, indicates a broad potential technology market. To provide direct and indirect support for marketing efforts, there are a variety of U.S. agency China programs available to U.S. suppliers. Familiarity with, and respect for U.S. technology is also being established through the thousands of Chinese students sent to this country.

Unfortunately, as stated above, the Chinese appear to believe that U.S. policies inhibit the transfer of technologies. Chinese officials have publicly contrasted their inability to obtain NASA's consent to a space science exchange with the eagerness of European national space agencies to develop S&T exchanges with China.

The Chinese concept of U.S. reluctance to transfer appropriate technology is, in itself, an inhibiting factor in the development of an orderly technology trade. It also inhibits the development of our China relationship as a whole. The Chinese have wanted the U.S. to play a key role in the technology transfer on which China's modernization depends. Chinese disappointment has been invariably manifested to every high level U.S. visitor to China in the last several years. The solution to the problem of expedited technology transfer lies on the U.S. side. If the U.S. is to maximize its influence on China's evolution as a constructive force in the world community, a solution must be found.

3) U.S. policy options for transfer of satellite telecommunications

It is assumed that China will continue to develop in much the same manner as at present. Economic reforms will be pressed. The Dengists will remain in power. China will remain open to needed technology imports, principally from the West and from Japan. The following three policy options represent the spread of options open to the U.S.

Policy Option One. Tighten up on the restrictions covering technology transfer to China. Prevent U.S. export of all satellite communications technologies which could be used for production in competition with American production, or could be used, either directly or indirectly, in military applications.

ADVANTAGES

A. In case China were to turn against us, we would have done nothing to strengthen her military capability.

B. China could not use American technology to turn out products that compete with American products and cost U.S. jobs.

DISADVANTAGES

A. Any roll-back of long-standing U.S. policy to respond to Chinese requests for U.S. technology, when the technology is non-damaging to U.S. national security interests, would damage the delicate fabric of U.S.-China relations and work against U.S. strategic and commercial interests in China.

B. Current Chinese irritation at U.S. technology export restrictions would be greatly increased while U.S. technology exports themselves would be greatly reduced to the advantage of U.S. competitors.

C. Other COCOM countries could use their discretionary authority to license exports restricted by U.S. national policy. The market would be left open to competing countries. Chinese interest in technology transfer from the USSR would also increase.

D. U.S. government programs for technical exchange with China would be considerably downgraded.

E. Pacific allies of the U.S. would be concerned because U.S. participation in Chinese economic development would be reduced along with U.S. influence on China. The concern would be magnified if, at the same time, we continued to press a program for transfer of military technology to expand Chinese military capability.

Policy Option Two. Continue our present policy of guarded response to Chinese interest in U.S. technology. Continue current attempts to simplify and expedite export licensing procedures. Broaden the U.S.-China technical exchange to include exchanges in satellite telecommunications technology.

ADVANTAGES

A. Being responsive, within limits, to PRC requests is a non-controversial approach which accords with accepted U.S. policy towards a friendly, non-allied nation.

B. To the extent that our own national licensing controls, and our use of COCOM, parallel those of our competitors, we would have an equal marketing opportunity with them in China.

C. Chinese preference for U.S. technology, which is now being priced in more competitive exchange dollars, would permit the growth of the U.S. market share. This would be particularly true in satellite communications where the U.S. is the acknowledged technological leader.

D. Inclusion of communications satellite technology in the S&T exchange agreements would improve the prospects for U.S. technology trade in this area.

DISADVANTAGES

A. Business as usual is essentially a laissez faire policy which fails to use the available influence of a positive American technology transfer program to enhance our China relationship.

B. A cautious, gradual improvement in our export licensing approach, which gives China half a loaf, is not going to dispel Chinese suspicion that the United States, as a matter of policy, is withholding appropriate technology from China.

C. Since U.S. competitors are able to use COCOM licensing referrals to better advantage than we, leaving COCOM as is, means further erosion of the U.S. competitive position. Also, U.S. national controls have generally resisted efforts to speed processing.

D. A tardy and limited technology exchange program, utilizing NASA and NTIA, does little to put the U.S. inside China's developing space and space communications industry.

POLICY OPTION 3. As the forerunner of a new positive program of U.S. technology transfer to China, take satellite communications as a model and develop a coordinated transfer program bringing together U.S. public and private agencies with existing China programs.

ADVANTAGES

A. Satellite telecommunications technology transfers would be the first phase of a U.S.-China partnership in a joint program for development of civil use of space. This is a role for which the U.S. is best suited, although Europeans, Japanese, and of course, Russians, would also like to play it. The U.S. would be wired into the Chinese space program from top down. Presumably, we could put up with envy and chagrin in Moscow. (In his August, 1986 speech in Vladivostok, Gorbachev proposed Chinese-Russian space cooperation.)

B. China-U.S. relations would receive a powerful stimulus. The U.S. would be helping to justify the Dengist opening to the outside world by our willingness to take the initiative in a program to assist Chinese modernization in a highly visible technical area, and one in which the U.S. has acknowledged technical superiority.

C. Chinese suspicions of a restrictive U.S. technology transfer policy would be eliminated.

D. The existence of a graduated program of satellite communications technology transfer would, in itself, help to create in China conditions for a successful transfer through a graduated program of phased technology absorption. The program would include provisions for upgrading and modernizing the Chinese satellite communications production infrastructure to support an advanced satellite communications system. For their part, the Chinese would be forced to develop an overall strategy for communications development in which satellite communications would have an allotted place.

E. A positive graduated program for technology transfer in satellite communications takes advantage of the rare convergence of views within U.S. government agencies on the value of such a program. The study team obtained converging views from the following U.S. agencies: State, Commerce, DOD, NASA, NSC, EXIM, TDP, NTIA, and COMSAT.

F. A positive program opens the possibility of utilizing a number of available U.S. agency programs in the first concerted U.S. technology transfer effort. Programs include the following:

(i) NASA space science exchange (not yet signed by the U.S.).

(ii) NTIA telecommunications exchange.

(iii) Commerce-supported U.S. space company trade delegation and technical mission including study of technical transformation of Chinese space infrastructure.

(iv) Commerce' Dalian Management Institute. (Satellite communications management program.)

(v) OPIC communications investment mission.

(vi) TDP feasibility study for Chinese satellite communications management and earth segment refurbishment contracts. (Coordinate study proposal with Dept. of Commerce U.S.-China Industrial Exchange Agreement.)

(vii) EXIM precommitment to support U.S. firms responding to Chinese satellite RFP or technical sales possibilities developed through missions or exchanges.

(viii) Committee for Scholarly Communication with the PRC (National Academy of Sciences) review of Chinese student exchange program for possible satellite communications-related studies at U.S. universities. In consultation with NASA, COMSAT, NASA and the National Council.

(ix) Telecommunications Committee of the National Council, develop program proposals for pressing the U.S. commercial advantage through coordination of U.S. commercial technology sales with U.S. agency program efforts.

(x) United States telecommunications training institute. (Inform appropriate Chinese agencies of availability of satellite communications courses in U.S. company facilities. Embassy Commercial Section to do the informing.)

G. U.S. space companies seeking a China market position would find that U.S. agency program support had resulted in the opening of some formerly closed segments of the PRC satellite communications support infrastructure.

H. Technology licensing would be handled in a unified fashion rather than through single submissions for individual approval. A list of basic satellite communications technologies to be offered to the Chinese would be drawn up by Commerce with the advice of COMSAT and the National Council.

I. COCOM would be made to work to the U.S. advantage by U.S. submission of a unified satellite communications technology list (already cleared at U.S. national level) for blanket approval in advance of possible export to China. The U.S. would not have an exclusive on this technology export possibility. Other countries could subsequently offer the technology to China. The U.S., however, would have the jump on its competitors, and no other country would be in a position to offer as complete an array of technologies as the U.S.

J. The Pacific allies of the U.S. would be heartened by evidence of U.S. determination to assist China's development in areas other than conventional arms. They would also welcome expansion of Chinese satellite communications which link China with the outside world and inhibit China from turning back inward.

DISADVANTAGES

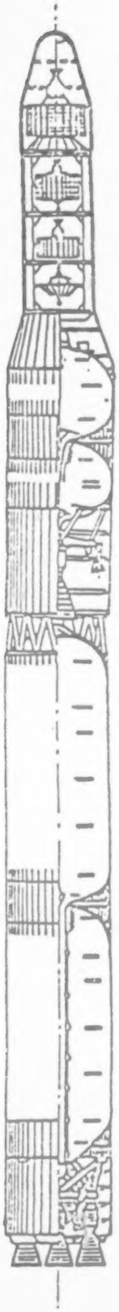
A. Even though Chinese civil communication improvement is brought about by satellite communications technology transfer, Chinese military communications would be strengthened as a byproduct.

B. It is extremely difficult to weed out of satellite communications systems technology those items which, if transferred, might be of assistance to China's strategic missile program. The U.S. would thus assist the development of this program, even if indirectly.

C. There is no guarantee that, after the U.S. has developed an approved satellite communications transfer program, the Chinese will not decide to opt for satellite communications technologies offered by competing countries with price subsidies or with other commercial enticements the U.S. cannot, or would not care to, match.

D. There would remain a possibility that, after the United States had become deeply involved in a combined U.S. government/U.S. business technology transfer program, the U.S.-China relationship would suddenly cool, and the program collapse. Differences over Taiwan, the Philippines, Korea, or a Chinese internal political turnaround, are all examples of possible chilling factors in the U.S.-China relationship.

Figure I



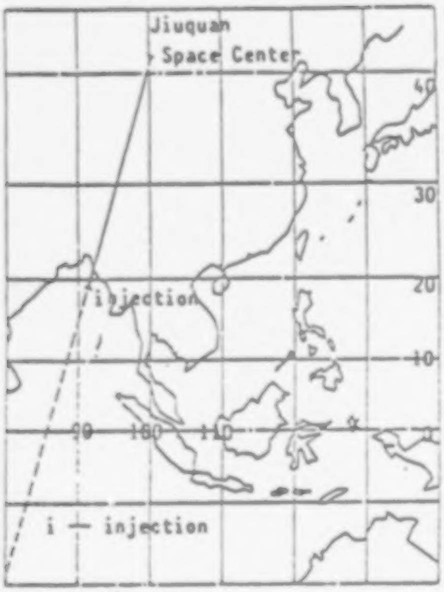
CZ-2C/OTM MULTIPLE SATELLITES MISSION

- * CZ-2C: Long March 2C Launch Vehicle.
- * OTM: Orbit Transfer Module is a small upper stage used for speeding the satellite into higher orbit.
- * Lift-off mass: 191,000 kg.
- * Lift-off thrust: 284,000 kg.
- * Overall length: 38.4 m.
- * Maximum diameter: 3.35 m.
- * Upper fairing diameter: 2.25 m.
  Static envelope diameter: 2.0 m.
- * Lower standard attach fitting diameter: 1.6 m.
  Lower OTM maximum diameter: 1.5 m.
- * Parking orbit payload capacity:
  1,700 kg(H_p=200 km, H_a=1,000 km, i=63.4)
  1,200 kg(H_p=200 km, H_a=900 km, i=98)
- * Usable weight for satellites and their OTM: 1,000 kg(i=63.4, H_a=1,000 km.)
  750 kg(i=98, H_a=900 km.)
- * Separation:
  Nose cone fairing & two side doors fairing:radial separation; upper satellite: axial separation; lower satellites:radial separation (frisbee deployment.)
- * OTM are fired at apogee point.

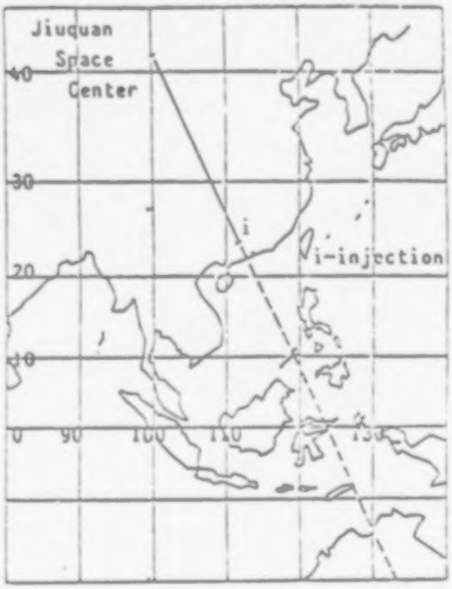
Figure II

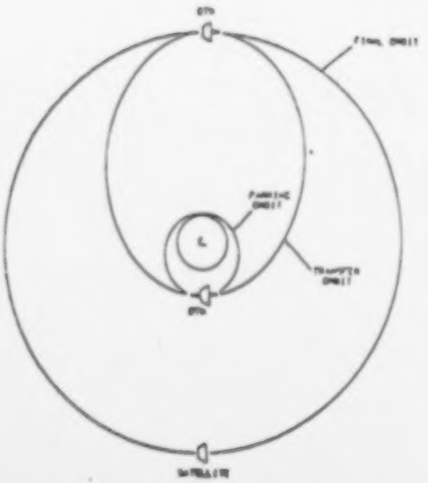
CZ-2C/OTM MULTIPLE SATELLITES MISSION.

CZ-2C/OTM SSO MISSION.


Jiuquan
Space Center
40
30
20
10
0
i injection
90
100
110
i — injection

CZ-2C/OTM MISSION. (i=55-70 deg.)


Jiuquan
Space
Center
40
30
20
10
0
90
100
110
130
i
i-injection


OTM
FINAL ORBIT
PARKING ORBIT
TRANSFER ORBIT
OTM
SATELLITE

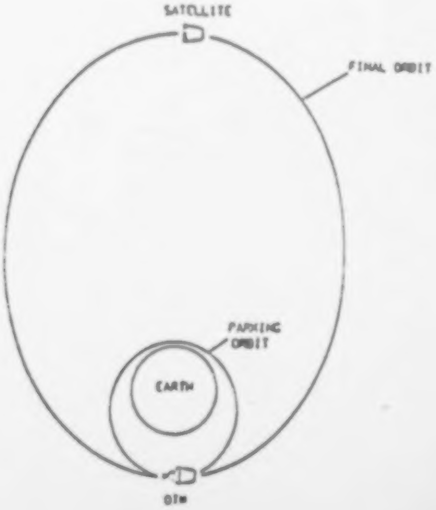
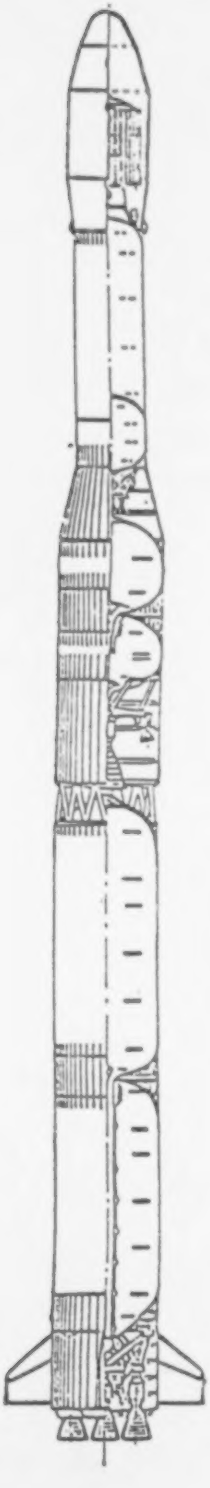
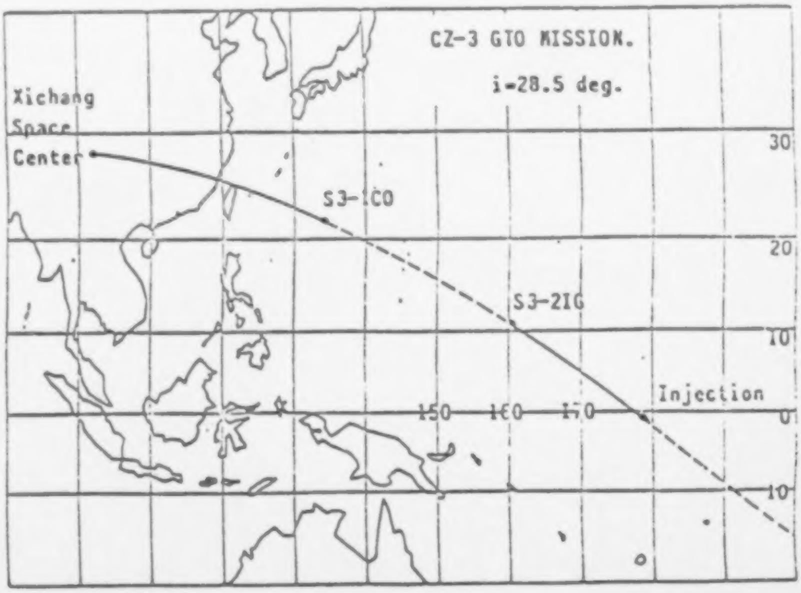

SATELLITE
FINAL ORBIT
PARKING ORBIT
EARTH
OTM

Figure III



CZ-3 GTO MISSION.

- CZ-3: Long March 3 Launch Vehicle.
- Three-stage. Cryogenic 3rd stage.
- Lift-off mass: 202,000 kg.
- Lift-off thrust: 284,000 kg.
- Overall length: 43.25 m.
- Maximum diameter: 3.35 m.
- Diameter of 3rd stage: 2.25 m.
- Fairing diameter: 2.60 m.
  Static envelope diameter: 2.30 m.
- GTO capacity: 1,300 kg.
  H_p = 200 km.
  i = 28.5 deg.
- Suitable for launching PAM-D class communications satellites, such as:
  HS-376 and RCA S-3000.
- Separation: axial separation.


CZ-3 GTO MISSION.
i=28.5 deg.
Xichang Space Center
S3-1CO
S3-2IG
Injection
150
160
170
30
20
10
0
10

Reference

TABLE I
TV Stations and Production

	Television Production		Transmission Facilities	
Year	Total	Color Sets	Stations	Relay Stations
1985	16,220,000	4,100,000	204	507
1984	9,960,000	1,290,000	--	--
1983	6,840,000	531,000	52	385
1982	5,920,000	288,000	47	328
1981	5,394,000	152,000	42	265
1980	2,492,000	32,000	38	246
1979	1,329,000	9,500	38	238
1978	517,000	--		

In 1985, the PRC State Statistical Bureau changed its method of reporting transmission facilities. Prior to that date, it distinguished between television centers and relay stations. Centers were defined as stations with program originating authority. For 1984, the Bureau's report did not include data on radio and television stations, the number of which multiplied nearly four-fold between 1983 and 1985.

SATELLITE TELECOMMUNICATIONS
DEVELOPMENT IN CHINA

A chronology of important events

1956	Astronautics industry development begins, according to the Chinese, "out of nothing."[1]
1960	USSR technicians depart, thus ending technical assistance in production of liquid fuel rockets.[2]
1965	Beginning of research and design of first satellite and carrier rockets.[3]
1968	China Academy of Space Technology formed to coordinate space program.[4]
1970	Chinasat 1. April 24. 173 kg. China becomes fifth country to develop launch capability and launch its own satellite. Tracking, telemetry and command network of seven stations in place. Satellite circled the earth every 114 minutes, broadcast "The East is Red." Decayed March 23, 1983.[5]
1971	Chinasat 2. March 3. 221 kg. Experimental scientific. Tests solar cells. In space eight years. Decayed June 17, 1979.
1972	RCA Globcom erects first satellite earth station in Shanghai.[6]
1974	Long March-2 -- launch failure.[7]
1975	Chinasat 3. July 26. 1750 kg. Scientific satellite. Circled earth in 91 minutes. Decayed September 14.
	Chinasat 4. November 26. 1750 kg. Reconnaissance satellite. Returned to earth December 2. China is third country to master satellite return technology. Long March 2 problem corrected and all subsequent launches with this rocket are successful.
	Chinasat 5. December 16. 1750 kg. Meteorological satellite. Returned to earth January 27, 1976.
1976	Chinasat 6. August 30. 1750 kg. Scientific satellite. Decayed November 25, 1978.
	Chinasat 7. December 7. 1750 kg. Experimental reconnaissance satellite. Returned to earth December 10.

China becomes member of Intelsat. Leases 60 half-way international telecommunications circuits.[8]

1977 China Academy of Sciences organizes Space Science & Technology Center for space research.[9]

1978 Chinasat 8. January 26.1 Conducted scientific experiments. Decayed February 7, 1978.

Begin negotiations with U.S. companies for import of direct broadcast satellite.[10]

Joint tests with France and FRG on European satellite.[11]

Joint tests with U.S. (RCA) on Marisat.[12]

First Chinese aerospace delegation to the U.S. -- NASA invitation.[13]

1979 NASA and AIAA visits to China. Cryogenic fuels development revealed. China only third country to use cryogenic third-stage rocket.[14]

Deng Xiaoping visits Johnson Space Center in Houston.[15]

Sino-U.S. understanding on space technology. "Under suitable conditions," China will buy U.S. DBS.[16]

1980 China begins astronaut training (later abandoned).[17]

Satellite purchase postponed on grounds of "economic readjustment."[18]

Nippon Electric awarded contract for Beijing #3 ground station to be linked to Intelsat satellite.

1981 Chinasat 9. September 20. 240 kg. Triple launch. Space physics experiment.

#9 decayed December 26.

Chinasat 10.

#10 decayed October 6, 1982.

Chinasat 11.

#11 decayed August 17, 1982.

China (CAST) begins discussions with NASA for S&T exchanges.

1982 Chinasat 12. September 9. Scientific experiment. Recovered September 14.

1983 Chinasat 13. August 19. Scientific satellite. Recovered August 24.

China-Italian joint tests with Italian Sirius satellite.[21]

November 21. USG issues more liberal guidelines for licensing of technology export to China. Landsat ground station finally approved.[22]

1984 Chinasat 14. January 29. First successful launch with Long March 3 (CZ-3). Gas generator burnout prevents proper payload positioning. First-liftoff from new spaceport in Sichuan Province.

Chinasat 15. April 8. National rejoicing for successful launching of communications (test) satellite on CZ-3. Geosynchronous equatorial orbit.

Chinasat 16. September 12. Decayed September 29.

U.S. sends "presidential" aerospace trade mission to China.[23]

March 7. China and Germany sign agreement for space technology cooperation including joint development and manufacture.[24]

Canada's Spar Aerospace sells China ground station package valued at over Canadian $24 million.[25]

August. RFP for DBS issued.[26]

September 21. MOA/NASA space science exchange agreement, but implementation postponed until signing of overall "umbrella" space protocol.

1985 Chinasat 17. October 21. Resource survey. Recovered October 26.[27]

June 13. China Daily announces that China is ready to market space products and services.[28]

At Stockholm International Aeronautical Federtion Congress, China describes launch failures, provides launcher details.[29]

China opens new space launch complex to potential customers.[30]

July 15. China postpones RFP for DBS.[31]

People to People, NASA, AIAA groups of US aerospace technicians visit China.[32]

August 1. China begins 3-months of free trial on Intelsat satellite for educational T.V.[33]

1986 Chinasat 18. February 1. CZ-3 launch of "operational" commercial satellite. Geosynchronous orbit.

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2 Bradley Hahn, "China in Space," BJR, July-August 1981.

3 Jing Zhaoqin, 'China's Developing Space Program" Signal, Feb., 1986.

4 Bradley Hahn.

5 Launch information from three basic sources: (a) "Experimental Satellite Firmly in Position," Beijing Review, April 30, 1984; (b) Bradley Hahn; and (c) "China Inaugurates a Satellite Television-Network." USIA Research Report, April, 1986.

6 Karen Berney, "Communications Satellite Program," CBR, March-April 1981.

7 Jeffrey M. Lenorovitz, "Chinese to Demonstrate Booster Reliability," AWST, 10/28/85.

8 Karen Berney.

9 Bradley Hahn.

10 Karen Berney.

11 Sun Jaidong

12 Karen Berney.

13 Bradley Hahn.

14 Ibid.

15 Ibid.

16 Karen Berney.

17 Bradley Hahn.

18 AWST April 8, 1985.

19 Madelyn Ross.

20 AWST April 8, 1985.

21 Sun Jaidong.

22 Madelyn Ross.

23 Bradley Hahn.

24 *Aerospace Daily* 3/13/84.

25 Madelyn Ross.

26 Ibid.

27 Sun Jaidong.

28 *China Daily*, June 13, 1985.

29 Lenorovitz.

30 *Aerospace Daily* 2/25/85.

31 *Satellite Week* 7/29/85.

32 *AWST* August 15, 1985.

33 *Communications Today* in Chinese No. 10, 1983 pp. 8-9.

CASE STUDY

Satellite Telecommunications Technology
Transfer to China
Interviews Conducted

Washington

1. Export-Import Banks

   William M. Arnold, Senior Vice President

2. Department of Defense

   Fred Ikle, Undersecretary for Policy
   Donald Hicks, Undersecretary for Research & Engineering
   Jerry Sullivan, Deputy Undersecretary for International Affairs
   Steve Bryen, Deputy Undersecretary for Technology Transfer

3. Department of State

   Dick Williams, China Desk Office
   Stephen Schlaikjer, International Economist

4. Chinese Embassy

   Lu Jing Ting, Minister Counsellor for Science and Technology
   Jing Zhaopian, First Secretary

5. Department of Commerce

   David C. Bowie, Manager, Market Support Activities, Office of Aerospace Market Development

6. NASA

   Peter Smith, Chief International Political Programs
   Kenneth Pedersen (former NASA, now teaching Georgetown)

7. Office of Munitions Control

   Steve Komanelis, Special Assist for Space

8. OSTP

   Barbara Moore, Senior Policy Analyst
   Jay Keyworth (formerly President's Science Advisor)

9. Ford Aerospace

Bob Beach, Vice President
Bob Berry, Director

10. COMSAT

William Mayor, President, COMSAT General
Dennis Curtin, Manager Aerospace Projects

11. NSC

Gaston Sigur, Special Asst. to the President for NSC
David Laux

12. TDP

Dan Stein, China Programs Director

IN CHINA

1. China Economic and Trade Consultants Corp.

Zhang Dimo, General Manager, Information and Research Dept.
Zhou Mian, Vice President

2. State Science and Technology Commission

Wu Jiaxiang, Director, Satellite Office, Deputy Director, Hi-Tec Dept.

3. Ministry of Astronautics

Chen Shouchun, Chief Engineer, Scientific Research and Production Bureau.

4. China Broadcast Satellite Corp.

Wang Zhongchi, Vice President

5. Ministry of Posts and Telecommunications

Yun Jin, Deputy Director, Dept. of Science & Technology
Tan Xivqing, Deputy Division Chief, International Cooperation, Dept. of Science & Technology.

6. China Association for Science and Technology

Wu Ganmei, Director, International Conference Center for Science and Technology.

7. Beijing Institute of Control Engineering

Lin Jin, Engineer

4. General Electric (USA) - China Co. Ltd.

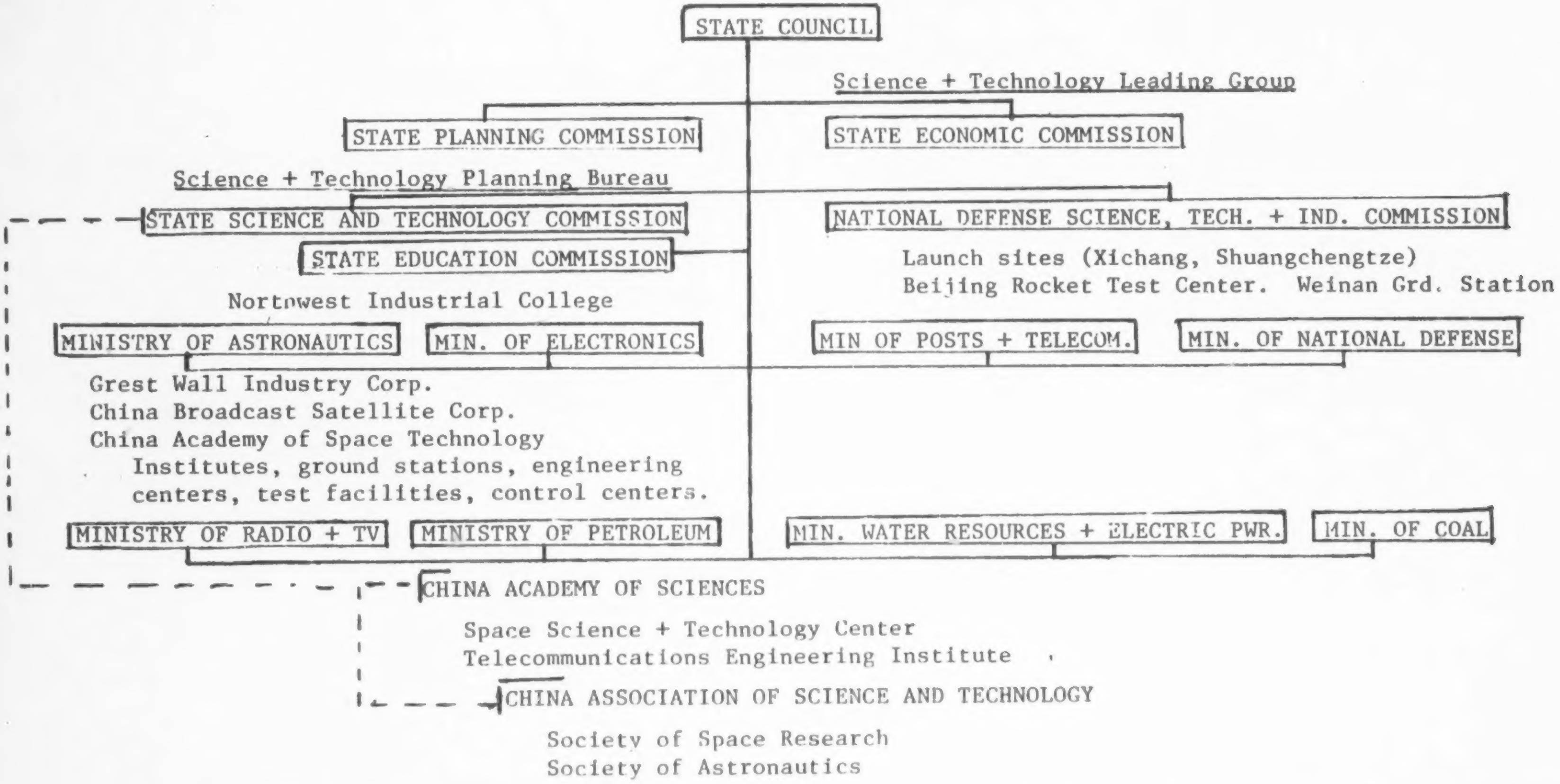
Richard Abington, President
Richard Kask

5. Honeywell, Inc.

Robert O. MacDonald, Director Business Development, People's Republic of China.
David T. Lee, General Manager, China Operations

CHINA -- SATELLITE TELECOMMUNICATIONS TECHNOLOGY TRANSFER

Chinese agencies responsible for selection, production and application of space communications technology


STATE COUNCIL
Science + Technology Leading Group
STATE PLANNING COMMISSION
STATE ECONOMIC COMMISSION
Science + Technology Planning Bureau
STATE SCIENCE AND TECHNOLOGY COMMISSION
NATIONAL DEFENSE SCIENCE, TECH. + IND. COMMISSION
STATE EDUCATION COMMISSION
Launch sites (Xichang, Shuangchengtze)
Beijing Rocket Test Center. Weinan Grd. Station
Northwest Industrial College
MINISTRY OF ASTRONAUTICS
MIN. OF ELECTRONICS
MIN OF POSTS + TELECOM.
MIN. OF NATIONAL DEFENSE
Grest Wall Industry Corp.
China Broadcast Satellite Corp.
China Academy of Space Technology
Institutes, ground stations, engineering centers, test facilities, control centers.
MINISTRY OF RADIO + TV
MINISTRY OF PETROLEUM
MIN. WATER RESOURCES + ELECTRIC PWR.
MIN. OF COAL
CHINA ACADEMY OF SCIENCES
Space Science + Technology Center
Telecommunications Engineering Institute
CHINA ASSOCIATION OF SCIENCE AND TECHNOLOGY
Society of Space Research
Society of Astronautics

SOURCES: National Council for U.S.-China Trade; *Aviation Week & Space Technology*; U.S. Embassy, Beijing; AIAA reports; *Nature*, November 21, 1985.

CHINA -- SATELLITE COMMUNICATIONS TECHNOLOGY TRANSFER

Satellite communications transactions with the PRC

(A partial listing for the period May 1984 to May 1986)

transaction	PRC entity	date	value	foreign entity
Satellite communications coproduction agreement. Memo of understanding.	MOA	1/19/84		E.B.Communications (Norway)
Sale of 26 earth stations + related equipment.	INSTRIMPEX	1/19/84	$16m.	Spar Aerospace Ltd. (Canada)
Launch reservation for two PRC satellites. 1987/88 period.	MOA	4/26/84		Arianespace (Fr.)
Satellite TV receiving equipment manufacture,	Anhui Electronic Ind.	3/84		Hans Kolbe (W. Ger.)
Earth station eqpt., follow-up order.	INSTRIMPEX	10/1/84	$3.8m.	Spar Areospace Ltd. (Canada)
Technical exchange protocol. Train Chinese engineers in design, production and assembly of sats..	MOA	11/7/84		MATRA (France)
Shuttle reservation. Two PRC direct broadcast sats. in 1988.	China Broadcast Sat. Corp.	12/84	$.5m.	NASA
Training in operations + maintainance of sat. ground stations. Memo of understanding.	MOA	12/28/84		Spar Aerospace Ltd. (Canada)
TV transmitting equipment for sat. network.	INSTRIMPEX	11/5/84	$20m.	Electronics, Missles and Communications (U.S.)
Earth station equipment.	Guangxi Imp. Corp.	12/7/84	$1m.	Aydin Corp. (U.S.)
Tech. exchange agt. Space S&T, sat. systems + carrier rockets.	MOA	1/28/85		Ministry for Ind. + Technology (UK)
Research exchange agreement, Civil use space satellites.	MOA	3/12/85		Ministry of Research + Technology (France)
Six satellite receivers (TVRO)	MOA	3/1/85	$9.5m.	Alactel-Thomson, S.A. (France)

Source: China Business Review, National Council for U.S.-China Trade. Does not include transactions held confidential by either party, or considerable value of equipment sold to China for use in production and operation of satellite communications network but not identified as such.

ADDITIONS

AUG. 15, 1986

Note - With the terrible typists of the Old Town Business Center: it is possible to reach a point where the addition of a comma, a crossed "t", or a dotted "i" means further near-interminable delay. The add-ons below were afterthoughts of the last week or so which would have been added, but would have meant additinal delays. They can be added to a final version, but would require additional time. They are presented here , because they could be significant in consideration of the subject.

B. 4 China as a competitor

Minister of Astronautics has lunch, August 18, with Congressman Nelson. The minister is then brought into the subcommittee's hearings on a commercial ELV. (Chack with the subcommittee staff on the ministerial delegation and their purpose).

C. 8 Non-commercial transfer modes

Note China's cooperation with international satellite-interest agencies. China is a member of INTELSAT, INMARSAT, the International Astronautical Federation, and various associated U.N. agencies. C. has attended every major international conference on space since 1980. As far as can be determined, none of this activity has yeilded traceable dividends for China's satcom program as much as it has informed outsiders on some of China's space activities.

c. 2 A formidable bureaucracy

When given the space objectives of other PRC agencies, CAST assigns its facilities to work on their projects. CAST turns out equipment for the Meteorological Bureau. (AWST 7/22/85)

C.4 Managers

Comment that management is a Socialist problem. The difficulty of converting Socialist bureaucrats into enterprise managers. Since it is not native to their experience, they need training.

D.2 U.S. Marketing Advantages

Hughes' alleged (by the Chinese) proposal for a joint-venture launch facility in Hawaii is denied by Hughes. Just one of the many possibilities being considered by Hughes, including Johnston Island near the equator in the Pacific. Sen. Matsunaga interested in a joint U.S.-Japanese space center in Hawaii. Launches from U.S. soil would be easier, and Hawaii is close to the equator with good launch avenues over the Pacific. (Harvey Meyerson, Sen. Matsunaga's office 224-6361. W. Post 6/16/86

B.2 China's satcom goals

As part of the PRC's international outreach, China and Brazil agree to cooperate in the manufacture and launch of a meteorological/remote sensing satellite. Costs will be shared. (AWST)

D. 2 U.S. sales

As indication of the market potential, Scientific Atlanta sold several million dollars worth of sat ground equipment in 1981 and remains bullish about China market development potential. (China Business Review)

Under U.S. agencies influencing the environment for U.S. business in China, include the cabinet-level commissions. The Joint Economic Commission (U.S.Treasury/PRC Ministry of Finance for macro problems) and the Joint Commission for Commerce and Trade (Dept. of Commerce/MOFERT for micro problems). China only country where we have two such commissions and thus another indication of the USG willingness to press development of economic interchange with China.

Under TTI, the Reagan quote. "Our century of experience has proven that telecommunications is a flexible resource-a resource whose abundance increases in step with the development it makes possible for all mankind. We have enthusiastically shared our experience with the world for a century, and we look forward to continuing that mutually regarding cooperatiion." Message to 1982 ITU Conference which gave rise to U.S. TTI.

Under U.S. licensing problems. U.S. suppliers understandably chafe under USG rigorous licensing procedures, but the government can pull itself together for categorical export licensing approval when sufficient commercial advantage is obtainable. For instance, a generally restricted and potentially rich China market for U.S. nuclear power equipment was opened when the Administration pressed an agreement with China for peaceful uses of nuclear energy. In the satellite telecommunications area, a U.S. interagency working group was able to agree on the licensing of a total technology export package which permitted the U.S. suppliers to compete on the RFP for a China satcom system. The fact of Europen competition spurred the U.S bureaucratic reaction. Nevertheless, it demonstrate that U.S. national approach is pos sible in obtaining approval for a broad area of satcom tech exports to China. Recent U.S. agreements to sell communications equipment (previously restricted for licensing) to India and Pakistan for use in non-military programs provides additional models for satcom tech transfer to China. ("U.S. to sell Pakistan restricted technology" Washington Times, 7/18/86)

Add several pertinent segments of the Telecommunications Protocol to the attachments.

E.2 U.S.-China relations.

In his May 28, 1986, speech to the Annual Meeting of the National Council, Ambassador Winston Lord reflected official views when he declared that China's reforms and the opening to the West are "irreversible". But it is not necessary to concede that the current Chinese leadership's policies are irreversible before agreeing that they head China in a direction which the U.S. hopes China will go. It is also possible for "China-watchers" to agree that China is more likely to continue in that direction than not, and that, by exercising its influence through economic and S&T cooperation, the U.S. can help insure that China continues to move in that favorable direction. Whatever China's ultimate economic, political and military role in the world, and there are those who speak of a Chinese 21st century, the U.S. has a national interest in maintaining a strong and expanding relationship with China. To that end, there are things we should be doing now in response to China's plea for technology transfer.

E.2 U.S.-China Relations

With regard to concerns of our Pacific allies about U.S. military technology transfer as against telecommunications transfer. Note that the Senate Foreign Relations Committee sent a letter to the President expressing concern over the trend in recent arms exports to the PRC. The letter asked assurance that the Administration continues to support preservation of the military balance between the PRC and Taiwan.

E.3 Option 3

Advantages

Military implications are manageable. Reasonable safeguards would minimize any direct advantage to the Chinese strategic missile program. In the agreement with the U.S. for a satcom tech trans program, the Chinese would be asked for a written undertaking not to employ the technology in military applications or to pass it to a third party without permission. The undertaking would be similar to that accepted in connection with transfer of neuclear technology to China for electric power development. The sanction on Chinese observance would be the absolute necessity for China to continue to receive U.S. technology transfer. Satcom tech trans reduces current mil. bias in U.S. tech trans.

High visibility of satcom tech trans program. Space communications has strong, favorable, international public image. It is the telecommunications of the global village. In the eyes of the U.S and Chinese public, it would be symbolic (more than any other technology transfer) of the continuing development of the relationship between the two countries.

Assistance in opening international satellite circuits to China would underwrite China's opening to the outside world and further guarantee against China's return to xenophobic isolation. Also assists direct U.S. communication with China thereby assisting commercial contact and more circuits through which to channel U.S. influence.

No broad budgetary implications. U.S.Government contribution to joint program comes about through established and funded agency activities in China.

Catches up overall U.S. tech trans program with China. Satcom tech trans has been the area in chich we have been slowest to reach agreement with the PRC. It was hoped to have a satcom tech exchange agreement ready for Reagan's trip in April 1984.

Positive program of satcom tech trans enlarges U.S. participation in PRC development by opening two avenues for broader cooperation. One is telecommunications with an opportunity for U.S. telecommunications companies to gain a foothold in a priority Chinese market. The other is space, with the opportunity for U.S. aerospace companies to access a market which will grow as China emerges as a space power. From collaboration in comsats it is easy to move on to collaboration on other sats - meteorological, landsats, navsats, and scientific sats.

Commerce, supplemented by NASA, would act as the lead agency in the program of expanded satcom tech trans. A government agency must take the initiative in gathering together disparate government and private sector elements to form an organized program. Commerce is the logical lead agency because:

- Commerce is the only agency with the staff and the obligation to develop U.S. commercial interests abroad.
- A successful long-range program of tech trans must be rooted in commercial benefit and entrepreneurial participation.
- Commerce has constant and broad liaison with the affected U.S. business community and, through its commercial office in the Beijing Embassy, with the Chinese agencies to be involved.
- Commerce has three programs in China which would be used in this project. The telecommunications technical exchange under the newly-signed protocol, the Dalian management training program, and the work programs in telecommunications and aerospace under the U.S.-China industrial and technological cooperation accord- all three are germane. The latter might provide the best program focus.
- Commerce has the China desk, industry specialists, NTIA, and tecnology licensing responsibilities, so that a committee in Commerce would be needed to coordinate a common approach. The Commerce committee would then take the leadership in introducing the tech trans program to an interagency group (possibly the SIG Space Working Group) to seek overall USG approval and support.

The tech trans program would offer an opportunity to reexamine the pending NASA-MOA protocol on a space science exchange. The protocol could be broadened, with the advice of aerospace company representatives, to include areas which give promise of commercial follow-up. The added exchanges under the protocol need not be limited to satellite communications. They could include any promising aspect of satellite development, including those areas (photo reconnaissance for one) in which the Chinese have shown advanced technical capability and could contribute to the exchange. A NASA agreement with the Chinese would start to repair the imbalance under which the U.S. has gone quite far in space with the Russians but has not even gotten off the ground with the Chinese.

Satellite communications is the ideal medium for a pilot program of coordinated USG/private sector tech trans because:

- China needs it, and knows that it needs it.
- Satcom enjoys a top priority and can claim available budgetary, personnel and management resources.
- China has developed its own satcom tech to the point where it can handle transfers of advanced technology.
- Satcom is a discrete, definable, and manageable set of technologies, so that both sides know what they are dealing with, and what to program.
- U.S. is preferred supplier and U.S. companies can use a cooperative program in satcom to branch out into other opportunities in telecommunications and aerospace.
- U.S. suppliers unafraid of building technological competition.
- U.S. suppliers can build market by working through network of existing U.S. agency programs.

Policy Option Three - DISADVANTAGE. China is already a competitor in the provision of satellite lift. Helping China to become a competitor in satellite technology is asking for trouble. When we help put China into space we are not only building competition, but cooperating with Communist China in a very high technology area.

China, 1986 Dengist economic policies are working so well that China's growth rates are double those of the Soviet Union. China's successful experimentation with market socialism presents a challenge to those in the Kremlin who cling to socialist economic orthodoxy at a time when Comrade Gorbachev is looking for new answers to old Soviet problems. The Soviets may eventually have to follow down the road of Chinese reforms as world Socialism moves to the right.

China 1986 China's march towards a market economy, already stimulated by the growing connection with Hong Kong and the Hong Kong Chinese, will be accelerated with the incorporation of the former colony, its laissez-faire economy intact, in 1997.

Policy Option Three - ADVANTAGE. Jerry Grey, president of the International Astronautical Federation says the U.S. is certainly sliding backwards in a number of areas relative to other countries. The commitments of the Soviet Union, Western Europe, Japan and China are cited in this connection in a report by theAmerican Institue of Aeronautics and Astronatuics. (A collaborative effort with China, besides adding to NASA's purpose, would combine the strength of the two national programs.)- MY COMMENT

Rail Transportation Division
(Founded 1920)

The American Society of Mechanical Engineers

REC'D MAY 30, 1986

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A REPORT COVERING THE

RAILROADS OF THE PEOPLES REPUBLIC OF CHINA OPERATIONS, ROLLING STOCK, STANDARDS AND PLANNING EFFECTS OF INTERFACE AND TECHNOLOGY TRANSFER BETWEEN NORTH AMERICAN RAILWAYS, RAILWAY SUPPLY COMPANIES AND THE ASSOCIATION OF AMERICAN RAILROADS (AAR)

Requested by the

United States Senate, Office of Technology Assessment

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A. ABSTRACT

In the past decade of rather open communication with the Peoples Republic of China, there have been several dozen invitations and visits to China by US and Canadian railroads, railway supply companies, and the Association of American Railroads. Many PRC railroad officers, engineers, transportation specialists, and planning experts have visited and studied in the USA. Most of these were from the China Academy of Railway Sciences which is the design and research arm of the PRC Ministry of Railways.

A number of PRC engineers have worked for the AAR in a special cooperative program over the past five years. The majority of PRC engineers were visiting scholars, who studied for one or two years in many of the major universities and technological institutes in US. A number took courses and qualified for advanced degrees.

In the PRC, railroads are the primary inter-city and inter-regional transportation mode for both passengers, and freight. Their still expanding railway system is based upon US/AAR, rather than European/UIC rolling stock, signalling, track and operational standards.

The Peoples Republic of China plans to emulate modern AAR style freight train operation and throughput capabilities on selected lines by the year 2000. We believe they will make major strides in this direction, and will be carrying more originated tonnage than US and Canada combined within fifteen years. US/AAR style trains will raise productivity per freight

train about triple their present levels. PRC will build North American style locomotives and freight cars, and run longer heavier trains. Few American builders, and supply companies, will have more than token equipment orders, since PRC primarily desires contracts for transfer of our technology to their country. Unless a large US-PRC international trade develops for what she has to sell (mainly coal and minerals), it seems unlikely that US would ever get significant orders for freight cars, electric locomotives, rail, track, and signalling equipment.

B. EXECUTIVE SUMMARY

1. Peoples Republic of China has chosen Railroads as their primary inter-city and inter-regional transportation mode, and has chosen North American Association of American Railroad type of railroading to emulate.

2. PRC recognizes their best opportunity to double and triple their railway capacity is to emulate North American AAR style railroad operation, rolling stock and support facilities. They will make this change over as fast as they practically can.

3. In regard to AAR type rolling stock and components, China will not import or adopt any technology until she has tried this out, and is certain that it will satisfactorily serve her needs and conditions.

4. PRC, with at least as much coal reserves as North America, must increase its coal production and delivery 2 1/2 times from the present 400 million tonnes annually to 1000 million tonnes, (1.2 billion US tons) in the next 10-15 years. This will provide a large international coal traffic to bring in much needed export revenue to reverse their trade deficit.

5. China will only import products, equipment and technology in areas where her own designs and manufactures do not provide the performance levels and reliability commonly and regularly produced by our equipment.

6. China's prime interest is in licenses, and joint ventures with our railway supply companies, to use, build and improve their manufacturing, quality, performance. They desire to use our technology to help them ultimately to sell their railway products in the world market.

7. For other than diesel-electric locomotives, where General Electric, Erie, PA, has sold some 422 at about $US450 million, and will sell selected component technology, total orders, royalties and license fees to date from China are probably not over $US10 million. We can expect to see more joint venture companies in a number of railway product areas beside the recent "first." This involves General Railway Signal Co., Rochester, NY, and the China Signal Manufacturing Company, where half the officers, including president and V.P. Manufacturing & Quality Control, will be U.S. citizens living in China.

8. China desires to be current on AAR standards, activities and would like AAR assistance from time to time. Until their R & D facilities are updated, they would like AAR to test a number of their railway products and equipment.

9. We expect continued strong competitive pressures from high levels of other potential railway equipment suppliers, particularly from Great Britain, France, West Germany and Japan.

C. SUMMARY OF TECHNOLOGY TRANSFER, PRODUCTS AND EQUIPMENT

1. Locomotives

Because of relative shortage of petroleum, China has decided to rely heavily on electrification of major high density traffic routes to replace steam locomotive power. On other routes, diesel-electric locomotives will replace steam motive power. China's own designs of electric and diesel-electrics have not been able to match reliability and performance of French electric and US multiple unit diesel electrics.

a. Electric Locomotives

Alsthom of France is building 150, two unit electrics, which can be operated in multiple unit with another two unit electric, giving a total of about 15,000 tractive HP per train. China will import manufacturing and engineering technology to produce this type of electric locomotive. The value of this project is approximately $US270 million.

b. Diesel Electric Locomotives

China has a major need for performance and reliability of US/AAR style freight multiple-unit diesel electric locomotives. They have purchased 422, 4000 HP C30-7 from General Electric, and will import technology to manufacture a Chinese version of this type. The value of this is about $US450 million.

2. Freight Cars

Changeover to US/AAR type, high capacity, fast unloading bulk lading (coal, ore, minerals) 100 ton capacity freight cars, will be slow in coming. This is primarily because few routes have heavy enough rail (60 to 75 kg/m or 121 to 151 lb/yard). China's capability to roll 60-75 kg/m rail is limited at present. In the interim, PRC will build and use 70 tonne capacity (77 tons) coal cars having 92 tonnes (101.5 tons-202,860-lb) gross weight. This is close to our "70 ton" nominal capacity car 220,000-lb gross weight.

a. China's Coal Ministry is importing Pullman Technology Inc. design of a "70 ton AAR capacity" automatic bottom door unloading coal car. Fifty are under construction by the China Heavy Machinery Company under license from Pullman. It is expected from several hundred to several thousand more will be built.

b. China's Coal Ministry has purchased 200, Pittsburgh and Lake Erie Railroad 70 ton Coal Hopper Cars, for trial service of this very common car in North American Railroad fleets.

c. Intermodal and Boxcars

PRC is now seriously thinking of using containers, and has shown interest in possible purchase of perhaps 500 Trailer Train Company's now surplus 85 foot flat cars, converted to handle two 40 ft long international shipping containers.

d. They have looked at possibly buying some of Trailer Train Company's plain 50 foot, 70 ton capacity surplus railbox cars built in 1975-76. Clearances at the roof/eaves line in PRC's many tunnels and full truss bridges may preclude this. This clearance problem also affects carrying highway truck trailers in piggyback fashion as we do.

3. Brake Equipment

PRC has decided that the North American AAR type brake equipment is the modern type that they need for the very long 100-150 car freight trains. Unit coal trains of over 100 cars will soon operate on parts of new coal lines under construction.

a. 390 sets of ABDW have been purchased from both New York Air Brake and WABCO (Westinghouse Air Brake - Div. of American Standard), for new "70" tonne rotary dump coal gondola cars of PRC design.

b. The 422, new GE Diesel Electrics have WABCO 26-L Locomotive Brake Equipment, including WABCO 3 CDCL Air Compressors. Technology transfer and manufacturing is still to be negotiated.

c. All the previous 100 Alsthom Electrics and Diesel Electrics built 1960 thru 1974 have WABCO US 14-EL or 26-L Locomotive Brake Equipment. The 150 new Alsthom Electrics will have WABCO France Type PBL (push button locomotive) equipment.

4. AAR High Friction Composition Brake Shoes

China has technology transfer bids for AAR High Friction

Brake Shoes from ABEX, Griffin Wheel Co., and Railroad Friction Products Co. (Westinghouse Air Brake). There has not yet been a decision on this.

5. AAR Friction Draft Gears

Several hundred car sets of AAR draft gears (energy absorbing mechanisms attached to car couplers) have been supplied by Cardwell Westinghouse and Miner Enterprises. The present standard draft gear for freight cars is very similar to Miner gears of the early 1950's. PRC is interested in technology transfer, license or joint venture agreements. The 422 GE diesel electrics have National Castings Inc. draft gears.

6. AAR Type E, F and Rotary Car Couplers

Rotary Couplers and Yokes for unit coal train cars have been purchased from Amsted International (American Steel Foundries) (100 car sets), and National Castings Inc. (100 car sets). PRC is also negotiating for Technology Transfer with these companies for both AAR E and F styles.

The 422 GE diesel electrics have National Castings Inc. locomotive alignment control AAR couplers.

7. Car and Locomotive Wheels

PRC has a modern (late 1960's) integrated steel plant at Ma-An-Shan, Anhui province, (Under China Ministry of Metallurgy) where they produce all their freight and passenger car wheels and locomotive wheel steel tires. China uses wrought (forged) steel methods and heat treatment similar to ours. They are only interested in improving manufacturing quality, and service performance. China is not interested now in our cast steel type wheel processes. She supplied all the steel tired new locomotive wheels for the 422 new General Electric locomotives. PRC wheels and tires are what we call multiple wear, and all are heat treated.

8. Freight Car Trucks

PRC has been working with American Steel Foundries for a design of the ride control cast steel freight car truck in 50, 60 and 80 tonne sizes, adapted for China's track and train conditions. They also have shown some interest in National Castings Inc. Wedge Lock type of friction stabilized AAR freight car truck.

9. Roller Bearings

China has a Railroad Roller Bearing manufacturing facility which provides diesel electric and electric locomotive and passenger car roller bearings. They have only made limited numbers of freight car roller bearings and have need to upgrade and modernize their designs and manufacturing capability. PRC has had access to The Timken Company's technology through Timken's subsidiary, British Timken Ltd.

10. Automatic Slack Adjusters

PRC Railroads have not used automatic double acting brake rigging slack adjusters on their freight cars. They recognize the value in improved train braking and control of brake cylinder pressures, by automatically compensating for brake shoe, and wheel wear. They have purchased a few hundred of AAR styles from both Cardwell Westinghouse (type 2300-DJ) and SAB-NIFE (DRV type), primarily for their new PRC design 70 tonne (77 ton) unit coal train cars.

11. AAR Geared Hand Brakes

Up to the present, Chinese freight cars have used the simple PRE-1930 horizontal hand wheel and staff type hand brake at one end of each car. This winds the hand brake chain around the staff and can double or triple wrap the chain, loosing considerable force. PRC railroads are interested in the modern AAR geared hand brake. They have purchased a few hundred from Cardwell-Westinghouse (type -7400 AAR 66) and Miner Enterprises.

12. Passenger Car Designs

Railroads in China have a severe passenger train capacity problem. Virtually all main route passenger trains are overloaded and many passengers simply cannot get abroad. There is a main-line (not commuter) need to considerably increase the number of seats per car. At present, train lengths are being doubled from 14 or 15 to as many as 30 cars. Because of present platform length, this requires two stops at each station and much extra station time. To alleviate this, China is now seriously considering use of double deck mainline passenger cars.

a. China has had serious discussions with Pullman Technologies Co., who has built some 500 low alloy steel, 160 passenger Bi-level commuter cars, and 275 high level main line cars since 1960. In recent years, double deck designs for commuter service have been produced in Canada by Hawker-Siddeley, in France, Italy and Japan. No decision has been announced yet. This project may tie in with the $US 235 million World Bank loan to improve and modernize the PRC passenger car plant at Changchun, raising its capacity to 1000 cars a year.

b. Transit America (formerly the BUDD Company Rail Car Division) has visited China and made proposals for passenger and mass transit cars of their unique shot welded stainless steel designs. Since PRC has virtually no stainless steel manufacturing capability, they have shown only mild interest, although Japan is producing several experimental stainless steel car bodies for PRC railways.

13. Signalling, CTC and Interlocking

General Railway Signal Co. of Rochester NY, has just concluded an agreement with China and formed an equal share ($US 2.5 million each) joint venture with PRC Ministry of

Railway's China Signal Manufacturing Co. The new company is called CASCO, and is headquartered in the CSM Co. plant near Shanghai. The president and the manufacturing vice president are chosen by GRS.

CASCO will operate to improve design, quality and service performance (reliability) of existing and new designs of wayside and cab signals, centralized traffic control (CTC) and interlocking plants. CASCO will also introduce modern, up to date solid state vital circuitry and integrated micro-chip technology to China. Present signal and CTC equipment made in China is reminiscent of US in the late 1930's and 1940's. CASCO has the rights to sell its equipment, based on, or using GRS design in the export market. This includes the GRS rear end marker and brake pipe pressure transponder for trains without cabooses.

14. Classification Yards

China has design and manufacturing capabilities for freight car retarders for hump yards. These appear similar to Union Switch and Signal Div. (American Standard Inc.) types used in US. and Canadian Hump yards. They have let contracts to upgrade hump yard controls from strictly manual to semi-automatic with the Japanese. Chinese require very low coupling speeds (1-2 kmh) because they allow loads without very much bracing and dunnage which we require. Use of manually placed skates, to slow cars down on each class track, is PRC's common method of controlling car coupling speeds. Skates are common in Europe. PRC engineers have designed a hydraulic "final" retarder system to replace the labor intensive skate method (one to two men for three shifts a day for each of the 20 to 40 classification tracks).

Under the present GRS/CSMC joint venture, CASCO will ultimately undertake all improvements and modifications to hump yard controls, main group retarders, tangent point retarders, as well as an automated skate system of GRS generic design.

15. Highway Crossing Protection

Since there is very little automotive traffic in China, the PRC feels little current need for automatic train proximity actuated (electrically operated) with automatic crossing warning protection/gates. Manually actuated road and pedestrian walk gates are commonly seen in most parts of China. Warning lamps are commonly used, and crossing watchmen's shanties are heated with coal stoves. Multiple track crossings have a watchman and gate operator on each side of the tracks. Country railway crossings often are miles away from electrical pole lines. Only in the modernized special western business counties near Kowloon, would North American and European style automatic electrical gates, and warning signals be needed. CASCO, the GRS joint venture company will supply these designs and manufacturing know how, when required in the future.

16. Track and Roadbed

a. China recognizes she cannot approach our facility to install and manufacture new improved and heavier rail sections, until her steel making and rolling mill capacity capability is significantly expanded. Relative cost/price structures in US and China seem to preclude any meaningful quantities of US rail being purchased by PRC. China seems only interested in keeping abreast of our changes, standards, and service experience, on heavy duty and high density unit train routes. Because of the relative scarcity of suitable hardwood or softwood in China, PRC is moving rapidly to expand their use of concrete ties.

b. AAR has tested various PRC designs of concrete ties to enable the Chinese to determine how they would perform under trains using US/AAR 100 ton cars and modern locomotives wheel loadings, common in North America.

c. AAR is cooperating with China railroads, and is testing rail sections and concrete ties made in PRC on our FAST tract (facility for accelerated service testing) at the Pueblo, Colorado, Railroad Test Center. This will provide PRC engineers, with direct comparisons of the wear and performance effects, of many millions of gross tons from US and Canadian 100 ton capacity fully loaded cars, and locomotives, on their present "heavier rail sections" with our 132-136 lb/yard (66 kg/m) rail, various fasteners on both wood and concrete ties of several North American and European designs. PRC railway engineers were in residence at Pueblo during this testing.

d. The AAR has assisted several groups of PRC Ministry of Railroads, and China Academy of Railway Science people, prepare applications for World Bank loans. This has included detailed proposal writing in English for presentation to the World Bank. Included have been many of the dynamic test bench items in place at the AAR Pueblo Test Center, including full scale vehicle dynamic units, and roller dynamic units for testing the dynamic vibratory frequencies, stresses and performance efficiency of locomotives and cars. Considerable further test work on track and railroad vehicle dynamics may be done on contract for the PRC.

17. AAR has assisted PRC engineers in studying various types and combinations of computers, and data acquisition systems, which could be of considerable help to the China Academy of Railway Sciences in their research and test projects. Also, AAR assisted PRC in the collection, and display of operating traffic and equipment location data by modern electronic data processing equipment.

18. In April, 1980, The Vice President of the Research and Test Department of the Association of American Railroads received an informal Chinese request for an exchange of personnel. He responded by issuing an official invitation to the China Railway Society to name a railroad research visiting scholar to spend one year in residence at the AAR Technical Center in Chicago and to work on a problem of mutual interest.

The invitation provided for the reimbursement of the visiting scholar for living expenses and for his travel in the U.S. when relevant to the research.

This invitation, was followed immediately by an invitation from the China Railway Society, for AAR to bring a group of up to ten senior personnel in the railroad industry to China for mutual discussions. A group including U.S. and Canadian railroad personnel, FRA, and locomotive builders, visited China in June, 1980, for seventeen days. During the discussions in China, it was apparent that:

> The Chinese railroads had been nearly devastated during the Japanese occupation, the fighting of World War II, as well as the conflict between the Nationalists, and the Communists. Restoration had begun when, in 1967, the Cultural Revolution started. All experienced personnel were removed from their positions and personnel with no railroad experience were put in charge. On the succession to power of Vice Premier Deng in 1978, restoration of the railway system began again. Men who had been in charge of railroad operations in the early 1930's were put in charge and by 1980, very rapid progress was being made in restoring the railroads to effective operation. Over 800,000,000 passengers were moved in 1978 for an average distance of about 250 miles. Seventy percent or more of all goods were moved by rail. But there were problems to be faced.
>
> The Chinese were committed to construction of their own equipment. They did not have sufficient foreign exchange to buy large quantities of foreign equipment

> and they had no intention of turning over their technical future to non-Chinese.
>
> There was a great desire on the part of the Chinese to learn about the status of the world because of the near total isolation of the Chinese for decades from the technical literature, and absence of previous opportunities to visit other countries and to discuss railroad technology with peer groups.
>
> There was a preoccupation with heavy haul operations. These required the Chinese to think about heavier axle loads, longer trains, and all of the related issues. The group from the U.S. and Canada made it clear to the Chinese that the most important issue in heavy haul operations was braking. The Chinese had very old braking systems in hand that were entirely inadequate for the safe operation of heavy trains.
>
> The Chinese indicated their interest in continuing an association with AAR.

The primary objective of the AAR Vice President of research was to ensure that the Chinese realized how superior the North American freight system was to any other in the world. Therefore, he was attempting to ensure that the Chinese understood that North American technology was the relevant technology for their future operations.

While in China, the U.S. delegation and the Canadian members invited the Chinese to visit Canada and the USA. They accepted, and in the fall of 1980, a ten person delegation came to Vancouver to visit the Canadian railroads, and then to the U.S.A. to visit railroads. They were taken to Washington, New York, Norfolk, Atlanta, St. Louis, Denver, and San Francisco with many intermediate stops. The issues of primary concern were coal operations and handling, locomotive design and maintenance, and general issues of railroad operating practices.

The importance assigned to the mission was made evident by the fact that the head was the Vice Minister of the Railroad Ministry, soon to be Minister, and the senior advisor was the Commanding General for the Railroad Battalion, personally designated to be a member of the delegation by Vice Premier Deng.

Since 1980, there have been visits by two additional U.S. delegations to China and two Chinese delegations to the U.S.A. In addition, Chinese delegations visiting the World Bank or in the USA for other purposes have also had extensive railroad discussions arranged by AAR.

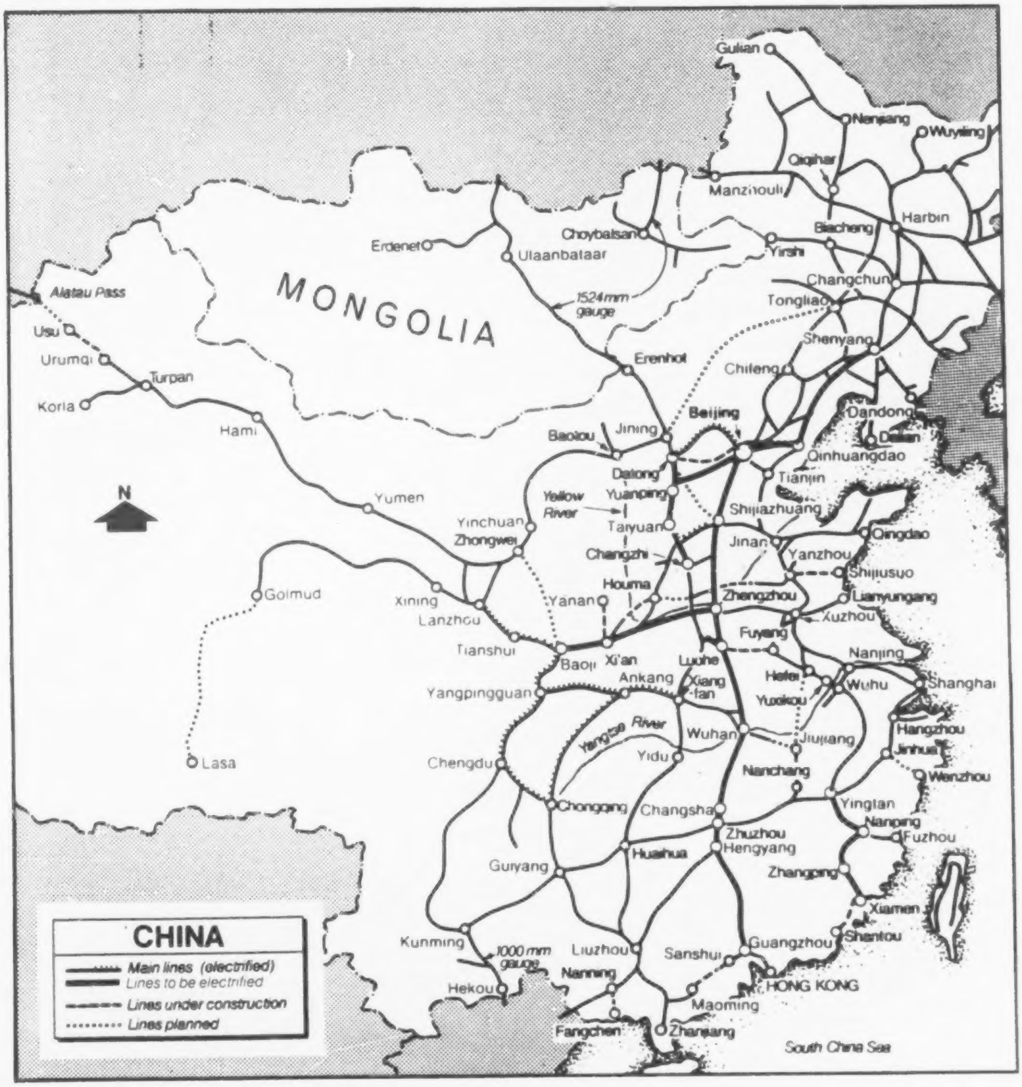
AAR has sent about eight of its staff to China to lecture for periods of up to a month. The Chinese have had five visiting scholars, sequentially, in AAR laboratories. A group from the China Academy of Railroad Research spent six weeks watching the operation of the dynamic test system in the Transportation Test Center in Pueblo, and the track laboratory in the Technical Center in Chicago as a basis for refining a proposal being made to the World Bank for new research facilities.

Because of uncertainties as to the adequacy of their rail, ties, tie fasteners and ballast under heavy load, in 1984, the Chinese sent a mile of track for installation in the Facility for Accelerated Service Testing at the Transportation Test Center. In May, 1986, two engineers reporting on the behavior of components in this system returned to China with significant new insight into revisions necessary to improve the design of a heavy haul track over which will move more than 200,000,000 tons of coal per year.

The relationships have been very good between the appropriate institutions in China and the AAR. Since the first visit, much younger men with no foreign experience but with good technical training and much enthusiasm have been placed in charge of Chinese railroad operations. The older men have been retained in the China Railway Society to provide guidance on major issues. The AAR has been helpful in introducing the younger leadership to the dynamics of technical change in the U.S. railroad industry.

The DOT has signed a protocol with the Chinese to provide for government to government interaction. However, the sharp reductions in funding by FRA for research, and the concentration of that research on safety issues instead of on a balanced program of increased efficiency and safety, will limit the nature of government-to-government exchanges. There will still be room for the private sector in the U.S., particularly the AAR, to have a useful program of interaction on programs of technology with the Chinese and for the U.S. railroad supply industry to sell products to China.

D. BACKGROUND AND PRC RAILWAY DEVELOPMENT



CHINA
Main lines (electrified)
Lines to be electrified
Lines under construction
Lines planned
MONGOLIA
N
Gulian
Nenjiang
Wuyiling
Qiqihar
Manzhouli
Harbin
Bacheng
Choybalsan
Erdenet
Ulaanbataar
Yirshi
Changchun
Tongliao
1524mm gauge
Shenyang
Alatau Pass
Usu
Urumqi
Turpan
Korla
Hami
Erenhot
Chifeng
Dandong
Dalian
Baotou
Jining
Beijing
Qinhuangdao
Tianjin
Datong
Yuanping
Taiyuan
Yellow River
Shijiazhuang
Yumen
Yinchuan
Zhongwei
Changzhi
Jinan
Yanzhou
Qingdao
Shijiusuo
Lianyungang
Houma
Golmud
Xining
Lanzhou
Yanan
Zhengzhou
Xuzhou
Fuyang
Tianshui
Baoji
Xi'an
Luohe
Nanjing
Hefei
Wuhu
Shanghai
Ankang
Xiangfan
Yuxikou
Yangpingguan
Yangtze River
Wuhan
Jiujiang
Hangzhou
Jinhua
Lasa
Chengdu
Yidu
Nanchang
Wenzhou
Chongqing
Changsha
Yingtan
Nanping
Fuzhou
Zhuzhou
Hengyang
Huaihua
Zhangping
Guiyang
Xiamen
Shantou
Kunming
1000 mm gauge
Liuzhou
Sanshui
Guangzhou
Hekou
Nanning
HONG KONG
Maoming
Fangchen
Zhanjiang
South China Sea

Figure 1. Railway Gazette International Aug. 1985.

PRC Railways have accomplished one of the most astonishing railroad construction projects in the 160 year history of this form of transport. Inheriting a war ravaged, wrecked and disconnected 23,000 km (14,500 mile) collection of multiple track gage routes in 1949, the PRC has reconnected, upgraded, and added some 24,000 km (17,500 miles) of new lines in standard gage 4'-8 1/2" (56 1/2" or 1435mm gage) in 35 years. A majority of the new rail routes were built through formidable geographical barriers. This includes heavy mountainous terrain in earthquake prone areas, as well as long stretches through deserts having sandstorms, and roving dunes. All provinces are now connected by rail with the exception of Tibet. At some future date PRC will build south from Golmud over the most difficult country in the world, a 3,000-4,000 meter altitude, cold dry mountainous region, leading to Lhasa, some 1500 km (about 1,000 miles) away. This will open up massive, untouched mineral resources.

In toto, PRC's railway expansion is similar to building some 10 transcontinental routes, such as from San Francisco to Omaha, Seattle to St. Paul, or Winnipeg to Vancouver. And all this has been accomplished in 35 years.

Mainland China with an area slightly larger than continental USA made the decision soon after independence, to utilize railroads as the prime means of inter-city and inter-regional transport. PRC has three times the population of US plus Canada, with 80% of their people concentrated in 1/3 their country. This dense population is in an area about equal to the US east of the Mississippi.

Thus their railway system has to carry an enormous passenger traffic (about one billion passengers a year) as well as move essential raw materials, agricultural products, and finished goods all at the same time. At present China's railroads originate about 1.4 billion tons, about 95% of US Class I railroads tonnage. PRC's tonnage originated will probably double by 2010. In the next ten years they will be originating 25% or more tonnage than US and Canada combined.

Chinese engineers and planners are very practical and down to earth. Because of PRC's traditional fiercely independent characteristics, they try to do most of the work with their own native materials and manpower resources. Since China does not have, nor is likely to have a large export trade in the near future with the technologically advanced western world, most of their enormous railway expansion is financed with internally generated capital.

The Russian "Intrusion" during the 1950's

During the 1950's, China accepted massive help from Soviet Russia which included several thousand Russian railroaders to assist PRC in getting their badly disjointed original network back into operation. One of the main reasons the Russians were sent home in 1960 was that, Soviet help was subtly directed toward making China technologically as well as politically dependent upon Moscow. Russia did not relish an independent modernized PRC just across their 5000 mile long eastern, and southern Siberian borders.

A prime example in the railroad field of Russian "colonial" thinking, and attitudes, was the "gift" of 1,000 large 2-10-2 steam locomotives, built 1931-1941, which had been displaced by Soviet post WW II electrification. They were well worn out. Upon receipt, PRC found they needed far more than just changing the track gage from 5'-0" (1525 mm) to PRC's standard 4'-8 1/2" (1435 mm). Most of these class FD locomotives had to be rebuilt at major cost, and in Chinese railroad shops at Chinese expense. The Russians said, each of these 15-25 year old locomotives was worth $US86,000, which was close to the new locomotive price in the US when they were built. PRC paid the Russians in cash, and then promptly sent the Russian railway engineers and experts home.

Knowledge of Railroading in Other Countries

PRC has always kept track of what was going on in US, Canadian and European railroading. Books, trade journals, technical society and trade association papers were continuously available through PRC's window to the western world, Hong Kong. They became convinced that North American railroading with Association of American Railroads standards was what they needed and should try to emulate.

North American emphasis on high capacity freight train transport is in contrast to the European style UIC (Union International Chemins de Fer--the "AAR" of Europe and UK), where the emphasis is on high speed, high density passenger service. UIC freight service equipment and operations are forced to adapt to short signal block distances, only 1/3 to 1/2 of those in North America. This requires short trains, tight scheduling and rather high, over the road speeds for freight. The short block distances, and passing tracks, limit British and European freight trains to about 2400-ft long, 30-eight wheel or 50-four wheel cars. UIC freight cars are braked about as high as our passenger cars both empty and loaded. This is about all the thermal braking a 36" (915 mm) dia. wheel can stand with a 10 tonne, 22,000 lb wheel load. Freight car brakes are also up to the practical wheel-rail adhesion limit, both empty and loaded. In this connection, it should be recalled, that 2/3 of all European inter-city freight tonnage travels part of its way by water transport, and relatively short distances by rail or highway.

As can be appreciated, this is the antithesis of China and North America, where, very long distance overland routes are the rule. Therefore, Peoples Republic of China naturally looks to US and Canadian AAR style railroading as that which they wish to emulate.

Of interest, most of China's northern railways had been built to US standards of the 1900-1930 period. Russian and Japanese influences through World War II continued these general standards. One exception was the track gage of the Trans-Siberian short line to Vladivostok. This line cuts across China's northern province Heilungkiang, from Man-Chu-Lin, through Chi-Chi-Haer and Harbin, and Sui Fue to Siberia's major Pacific "warm water" port, Vladivostok. Upon independence, PRC quickly changed the Russian 5-ft 0-in (1525 mm) track, back to their 4-ft 8 1/2-in standard (1435 mm).

Since then, all Soviet traffic must take the 600 mile longer route north, around the northern tip of Heilungkiang, which follows the Amur River much of the way to Vladivostok. China is now double tracking most of this line from Harbin west to Man-Chou-Lin. Large mineral and timber resources lie in the northern half of Heilungkiang.

International Services

At the present, China operates two through passenger trains a day from Beijing to Moscow. Locomotives, and the trucks on all cars are changed at the two border points, Man-Chu-Lin on the northern route, and Erhenhot on the Mongolian short line into Outer Mongolia. The northern route through Harbin takes about 7 days between Beijing and Moscow, and the Mongolian cut-off route takes about 6 days. This is a respectable overall average of about 44 mph. Most all the limited freight which is interchanged, is loaded into each others freight cars at the border.

A possible third connection to Russia has been talked of for years, and shown on many planning maps. This route will run some 600-700 km (370-440 miles) north and west out of Urumchi in Uighur, through Usu, and over the Sinkiang Mountains through Alatau Pass, and down to Dzrubha in eastern Kazakh S. S. R. (Kazakhstan). The section from Urumchi to Usu had been scheduled for completion in late 1985.

The Viet Nam Connection

The third and fourth international routes in existence for many years were actually built under French colonial rule of Viet Nam. The French built in meter gage for railroads, opening up foreign lands. A line from Hanoi was built, some 350 km (220 miles) to the Chinese border and later extended another 350 km (220 miles) to Kun-Ming the capital of Yunnan province. A connection to the port of Haiphong, on the Gulf of Tonkin, of about 60 miles (100 km) created a route some 500 miles long, to tap the resources of southern China's mountains and valleys. This route has had the track removed several kilometers north of the border since very tense relations continue between Beijing and Hanoi.

The fourth international route runs southwest from Nan-Ning, about 110 miles to the Viet Nam border at Ping Hsian, in standard gage (1435 mm). For the 100 or so miles southwest to Hanoi (161 km), the track was dual gage having three rails, two for meter gage (39-3/8"), and a third spaced 1435 mm (56 1/2") from the common rail for standard gage PRC cars. On the Chinese side, rails also have been removed for several kilometers, due to the tense political situation.

International Awareness and European Railway Equipment

PRC invited several west European countries, notably France and Germany, to display their wares and technologies with trade shows, during the 1960's and early 1970's. Reports indicate that the railroad sections of these exhibitions emphasized UIC style rolling stock, and brake equipments, and put heavy emphasis on electrification.

An early major and modern electrification was on the 677-km (420 mile) route from Bao Chi, south to Cheng Du, Szech-Huan. This single track line built in 1952-1955, crosses several mountain passes and has long distances of heavy 2% to 3% ascending and descending grades, much curvature, and dozens of tunnels and bridges. Under the original steam locomotive operations, throughput capacity was limited to the practical tractive force capabilities of two and three locomotive trains, which held train length to about 20-25 cars. Even with large 2-10-2 steam locomotives, and 30 to 40 trains a day (maximum practical long distance single track train movement capacity), this line could not have had a throughput of more than about 1000 cars a day.

In the late 1950's the French convinced PRC to use their 25,000 volt single phase AC form of electrification on this line. With all axles powered an electric locomotive can use all its weight for traction. This compares to about 40% of the total weight of a steam locomotive (including its coal and water carrying tender). Thus it is possible with a given weight of motive power to obtain 2 1/2 times (250%) the hauling capability with electric traction vs. steam. China had other reasons to electrify in this area of abundant rainfall and mountainous valleys. Mainly was to rapidly spread their electric network, by using hydro power. Thus this capital intensive electrification of the railroad appeared attractive. However, this project, raising throughput two and one-half times, could have been handled with four 3600 tractive horsepower North American style diesel electrics in multiple unit. In the early 1960,s neither west European nor Russian diesel-electrics were regularly operated in full multiple unit (both brakes and traction) for either freight or passenger service.

ELECTRIFICATION

China has made the decision to use electric traction on all new and existing heavy traffic routes which are reasonably close to hydro and coal fired steam electric power sources. This is because China has rather limited reserves of petroleum and massive amounts of good coal. Limited petroleum resources are also a reason China has chosen to use railways rather than highways as the prime inter city transportation mode.

Electrification now is fully operative on 2146 km (1331 miles) and partly in service on 1453 km (900 miles) for a total of 2238 route miles. Work is in progress on 1312 km (813 miles) and is planned for another 4212 km (2611 miles). Thus by the turn of the century, PRC expects to have 6035 miles of electrified heavy traffic routes. This will be about 15% of the total system in 2000 AD.

Figures 1 through 7 are from Railway Gazette International August 1985 and reflect information through mid 1985. A more detailed map with notes on various new and planned route construction is on Figures 8 and 9. This is from The National

Council for US China trade, Sept. 1984, "China Business Review." The main line PRC railway network on Fig. 1, 8 and 9 show the extent of the present 52,000 km (32,000 mile) system. Most of the railway routes and the heaviest construction has been in the eastern quarter of the country where 80% of China's 95,000,000 population lives. In addition to this there are reported to be about 20,000 km (12,400 miles) of "industrial" railways. Also there are about 3,800 km (2356 miles) of narrow gage lines in many of the counties of several provinces. Thus the total railway route length in PRC is close to 80,000 km (49,600 miles). This compares to approximately 150,000 route miles owned by US Class I railroads, 15000 in short lines or Class II, and some 32,000 miles in Canada for a total of 200,000 miles, (approximately 323,000 km).

The China Academy of Railway Science estimates that, some 20,000-km (12,400 miles) of new route will be needed within the next 15-20 years to adequately provide rail mass transportation service to all counties of all provinces in the south and west of China.

Figure 2 shows passenger and freight traffic on PRC railways since 1970. Note that passenger has doubled since 1975. Freight has risen from about 410 billion tonne-km (231 billion ton-miles) to 720 billion tonne-km (405 billion ton miles) in the 1975-1984 period.

Present traffic is being handled with a fleet of about 10,000 locomotives (about 7,500 steam); 18,000 passenger cars, and 280,000 freight cars.

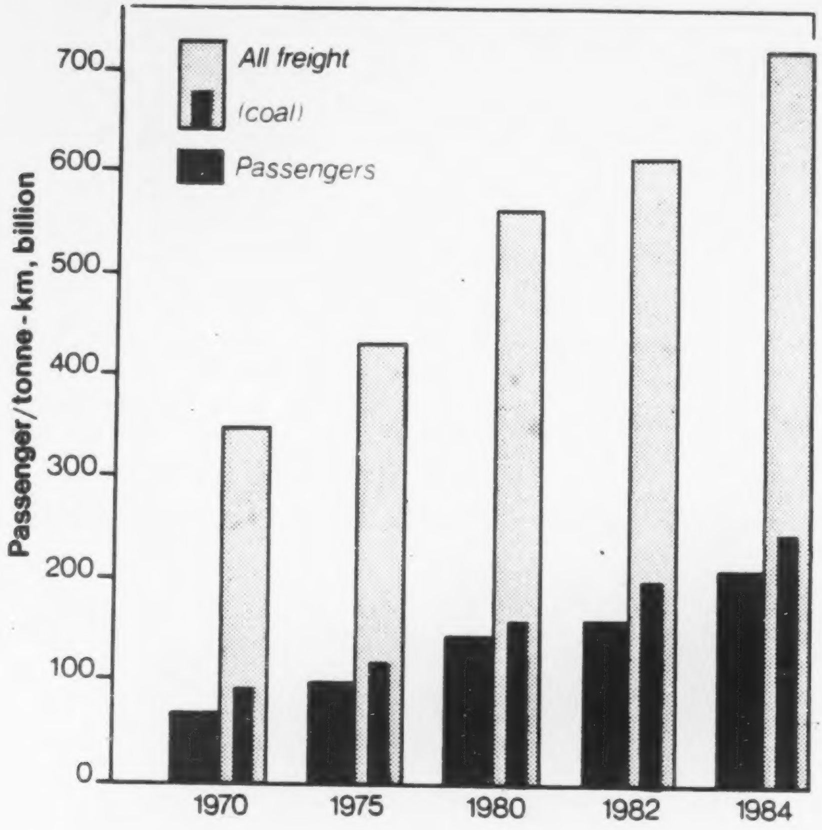


Figure 2. Railway Gazette International Aug. 1985.

China plans to increase its coal traffic from about 400 million tonnes at present to 1000 million by 1995. This in itself will add at least 1000 billion tonne km or 684 billion ton miles. Thus in ten years, China can be expected to handle as much originated tonnage and somewhat more ton miles than US, Canada, and Mexico combined.

Much of the increase in coal traffic will be handled by two major new routes being constructed. See map Figure 3.

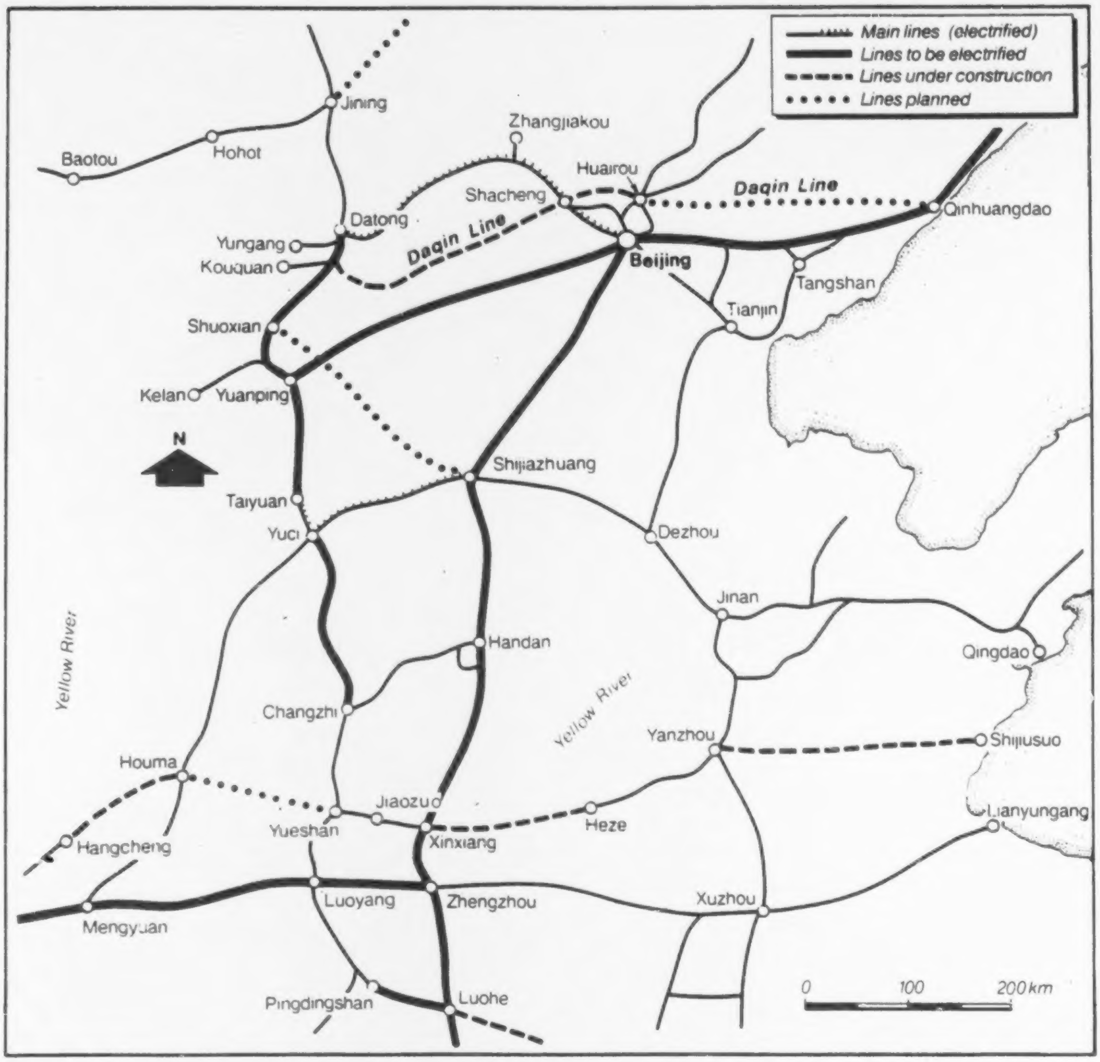

Main lines (electrified)
Lines to be electrified
Lines under construction
Lines planned
Jining
Baotou
Hohot
Zhangjiakou
Huairou
Daqin Line
Shacheng
Qinhuangdao
Datong
Yungang
Kouquan
Daqin Line
Beijing
Tangshan
Tianjin
Shuoxian
Kelan
Yuanping
N
Shijiazhuang
Taiyuan
Yuci
Dezhou
Jinan
Yellow River
Handan
Qingdao
Yellow River
Changzhi
Yanzhou
Shijiusuo
Houma
Jiaozuo
Lianyungang
Yueshan
Heze
Hangcheng
Xinxiang
Luoyang
Zhengzhou
Xuzhou
Mengyuan
0
100
200km
Pingdingshan
Luohe

Figure 3. Railway Gazette International, Aug. 1985.

1. The 673-km (404 mile) Daquin double track route from the Datung coal fields, passing north of Beijing and continuing east to a new coal loading port is being constructed at Qin Huang Dao on the China Sea. The route is expected to be finished in 1986 to Huairou north and east of Beijing. The existing line from

Beijing to Qin-Huang-Dao is being upgraded and electrified to handle increased coal traffic until the Daquin line is completed in 1991. 1700 meter long sidings (5600-ft long) will permit 130 car trains carrying 10,000 net tonnes (11,025 tons). The new coal cars planned will have 70 tonnes (77 tons) capacity and weigh 92 tonnes (101.4 tons) when fully loaded. China's steel mill capacity to manufacture 60 to 75 kg/m (150-lb/yard) is limited and in the early stages of unit coal train operation the nominal "70" tonne car will be used.

2. As shown in the lower part of Figure 3, the second major new coal route is a double track electrified line roughly paralleling the present central east west double track route from Xian to the sea coast. The line to Hou Ma is completed and forms a much needed second route to the south and west. Many coal mines are in the area west and north of Xin Xiang, and a second double track electrified route is needed to alleviate congestion on the Zhengzhou, Xuzhou line, to the present sea port of Lian-Yung-Ang. The 300 km section from Yan-Zhou to Shi-Jui-Suo is now under construction and includes special coal-ship, trans-loading facilities at Shi-Jui-Suo.

Of interest, Canadian Pacific Consulting Services designed the coal silo system (Figure 4) to be used for the output of 24 mines west of Datong and concentrates on flood loading of unit trains at four locations. CPCS also designed the rotary dumper facilities at Qin-Huang-Dao for dumping trains without uncoupling the cars. Rotary car dumpers are in place at Qintuan-Daol. Similar facilities are expected to be built at Shi-Jui-Suo.

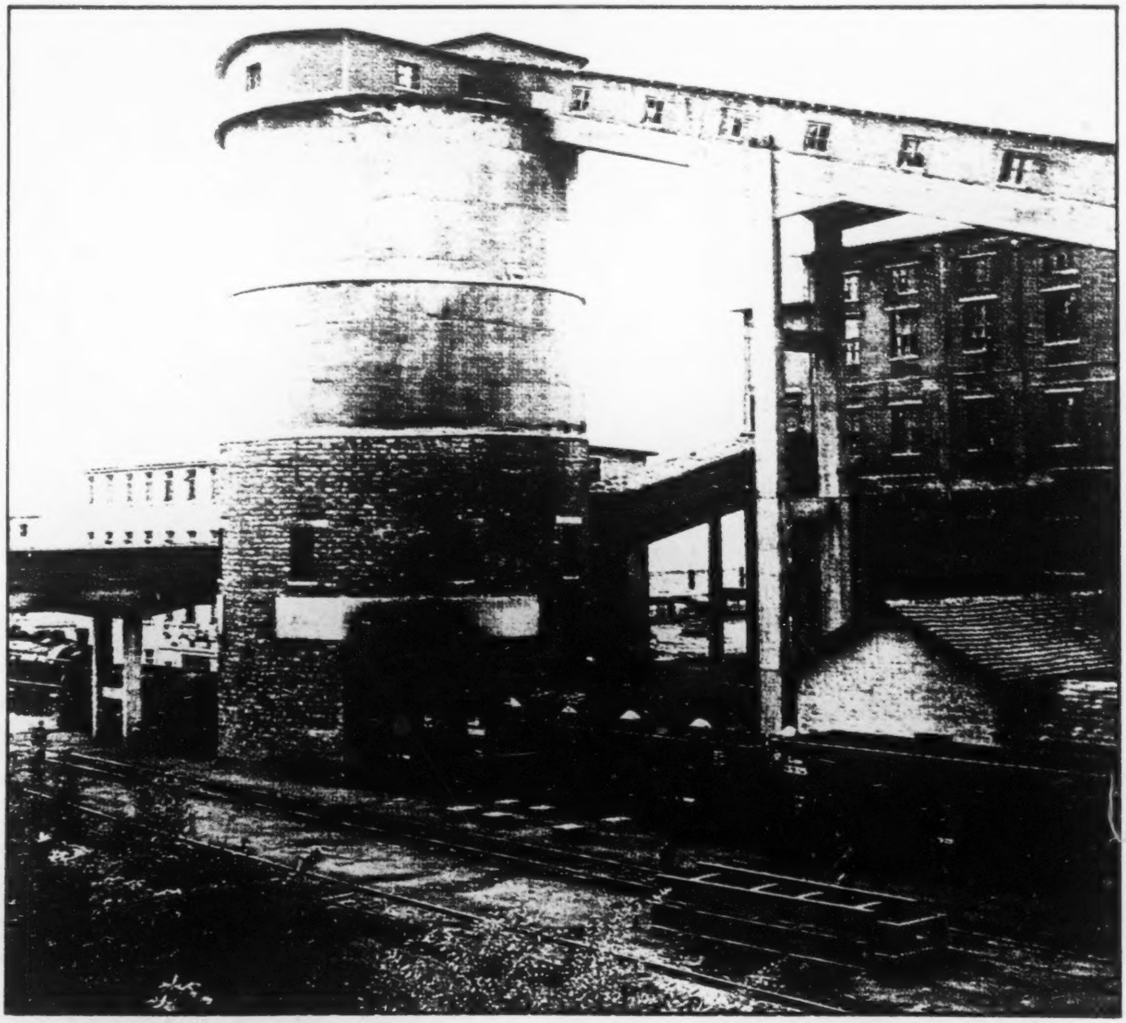


Figure 4. Silo For Flood Loading Coal

Two Car Rotary Dumpers at Qin Yuang Dao's new rail-ocean ship transloading terminal, can handle two 100-150 car rotary coupler coal trains simultaneously. Design used was recommended by Canadian Pacific consulting services. This is an update and improvement based on their 15 years experience at Roberts Bank, near Vancouver, B.C. Complete coupled trains of Canadian National, and Canadian Pacific coal cars have been dumped at the rate of 2 cars per minute. All CN and CP cars follow AAR standards, and have rotary couplers (See Figure 5). The large machine to the left is a car mover which pushes the two cars dumped forward and positions the next two loaded cars in the dumper. The car mover has enough power to move the whole 100-150 car train.

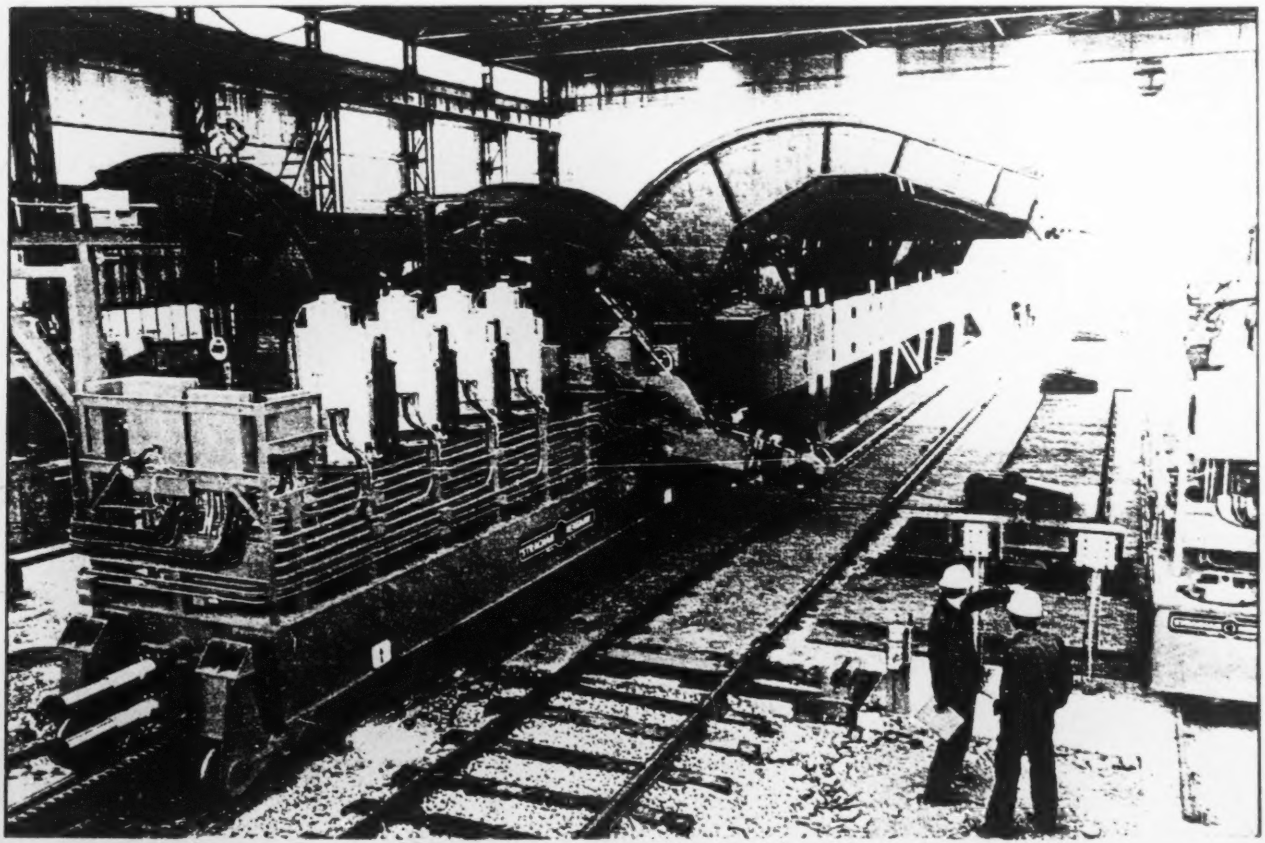


Figure 5. Railway Gazette International. Aug. 1985

E. APPENDIX -DETAILS OF FOREIGN TECHNOLOGY AND EQUIPMENT

Peoples Republic of China looks to foreign railroad technology to assist them in meeting their needs and goals. While PRC has deliberately chosen North American AAR style railroad operation and rolling stock designs as basic, they have found Europe, particularly France, was way ahead in railway electrification and electric locomotive design. China has spent some 20 years trying to get their own designs of electric and diesel-electric locomotives up to the performance and reliability levels of the French electric and USA diesel-electric designs. In recent years they have recognized the need to import both types of foreign locomotives plus the technology to design and build them in China. Therefore, two massive orders were placed in the last couple of years.

1. DIESEL ELECTRIC LOCOMOTIVES

Four hundred and twenty two C30-7 4,000 horsepower diesel electrics were ordered from General Electric Company. The first 220 of these six axle, six motor locomotives have been delivered and are in service on PRC railroads, see Figure 6. Diesel-electric traction gives most of the advantages of electric locomotives in the areas of high tractive effort, all weight used for traction adhesion, dynamic braking and smooth application of power or dynamic brake. These C30-7 diesel electrics have full multiple unit capabilities for both power and brakes, as is our AAR standard. Four to six of these units can be operated by one engineman giving a total tractive horsepower of 14,000 to 21,000. To date PRC has only operated two GE units in multiple giving 7200 rail horsepower.

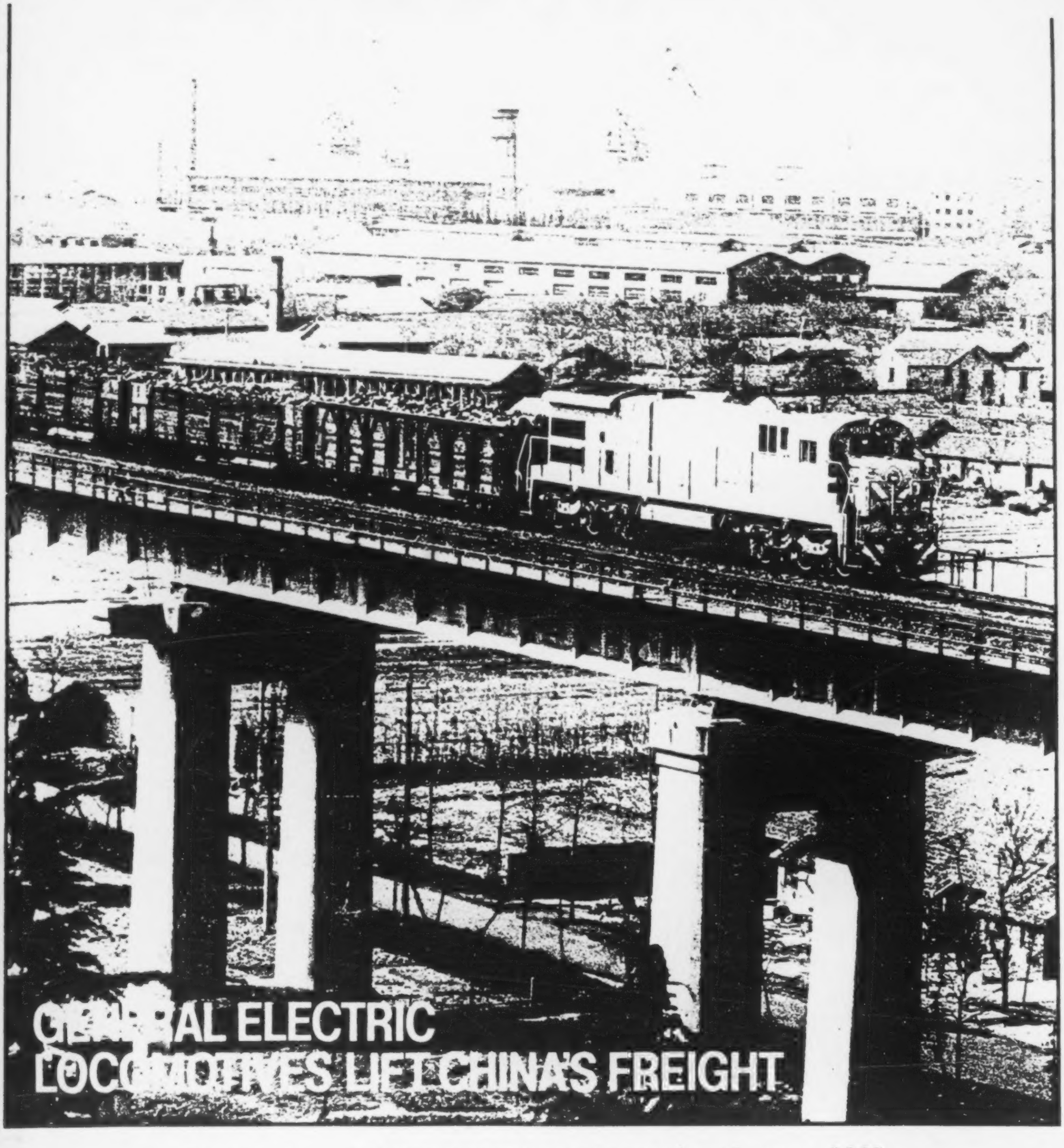

GENERAL ELECTRIC
LOCOMOTIVES LIFT CHINA'S FREIGHT

Figure 6. Railway Gazette International Aug. 1985.

Total maximum dynamic braking horsepower of four unit C30-7 consist would be approximately 14,400. These total horsepowers and resulting tractive and dynamic braking forces are much more than typical existing PRC general service cars could accommodate. However, the new designs of cars, particularly the unit train cars could stand these maximums.

The second group of 202 locomotives is now under construction at GE's Erie, PA plant. GE believes there is a good chance PRC will order more until they have their facilities equipped to build the basic GE design. General Electric engineers will assist the Chinese in constructing facilities to produce a number of unique GE design components.

These locomotives have two control stations in the cab for operation in either direction with the engineman on his "proper side" for visibility of brake signals and hand signals. There are two sets of power and brake controls. Brake equipment is AAR North American style type 26-L, provided by Westinghouse Air Brake along with WABD 3-CDCL air compressors. GE's standard North American brake rigging with truck frame mounted cylinders actuate the single brake shoe per wheel friction brakes. General Electric has hopes for further orders. Brake shoes are Railroad Friction Products Co. 2" Cobra type.

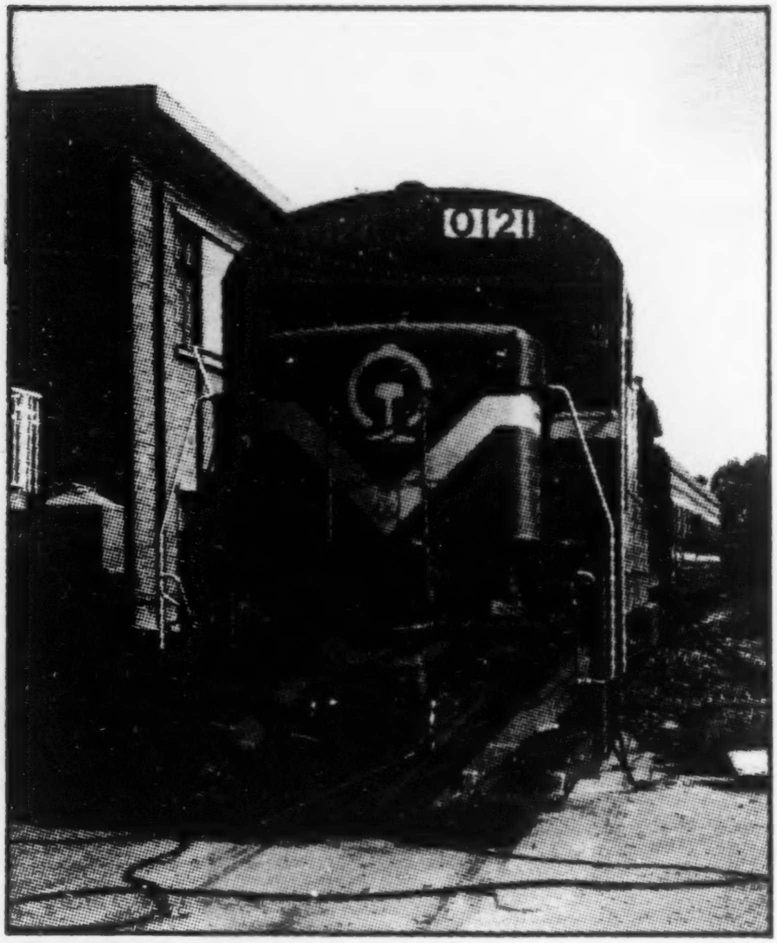
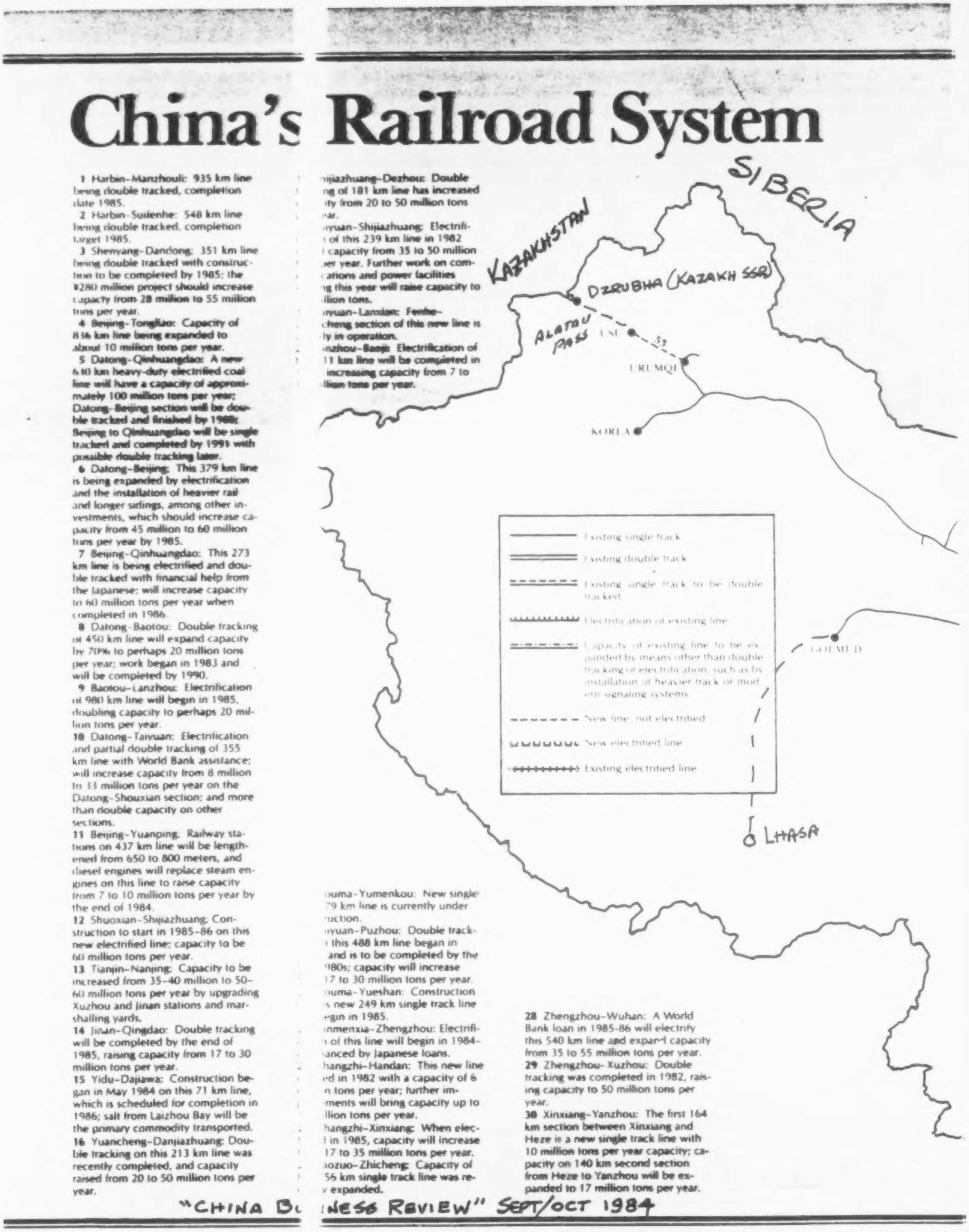


Figure 7. General Electric C30-7 4000 HP Diesel Electric PRC #0121 Undergoing Load Box Test at China Academy of Railway Sciences, Beijing Laboratory. Railway Gazette International, August, 1985.



China's Railroad System

1 Harbin–Manzhouli: 935 km line being double tracked, completion date 1985.

2 Harbin–Suifenhe: 548 km line being double tracked, completion target 1985.

3 Shenyang–Dandong: 351 km line being double tracked with construction to be completed by 1985; the ¥280 million project should increase capacity from 28 million to 55 million tons per year.

4 Beijing–Tongliao: Capacity of 836 km line being expanded to about 10 million tons per year.

5 Datong–Qinhuangdao: A new 640 km heavy-duty electrified coal line will have a capacity of approximately 100 million tons per year; Datong–Beijing section will be double tracked and finished by 1988; Beijing to Qinhuangdao will be single tracked and completed by 1991 with possible double tracking later.

6 Datong–Beijing: This 379 km line is being expanded by electrification and the installation of heavier rail and longer sidings, among other investments, which should increase capacity from 45 million to 60 million tons per year by 1985.

7 Beijing–Qinhuangdao: This 273 km line is being electrified and double tracked with financial help from the Japanese; will increase capacity to 60 million tons per year when completed in 1986.

8 Datong–Baotou: Double tracking of 450 km line will expand capacity by 70% to perhaps 20 million tons per year; work began in 1983 and will be completed by 1990.

9 Baotou–Lanzhou: Electrification of 980 km line will begin in 1985, doubling capacity to perhaps 20 million tons per year.

10 Datong–Taiyuan: Electrification and partial double tracking of 355 km line with World Bank assistance; will increase capacity from 8 million to 33 million tons per year on the Datong–Shouxian section; and more than double capacity on other sections.

11 Beijing–Yuanping: Railway stations on 437 km line will be lengthened from 650 to 800 meters, and diesel engines will replace steam engines on this line to raise capacity from 7 to 10 million tons per year by the end of 1984.

12 Shuoxian–Shijiazhuang: Construction to start in 1985–86 on this new electrified line; capacity to be 60 million tons per year.

13 Tianjin–Nanjing: Capacity to be increased from 35–40 million to 50–60 million tons per year by upgrading Xuzhou and Jinan stations and marshalling yards.

14 Jinan–Qingdao: Double tracking will be completed by the end of 1985, raising capacity from 17 to 30 million tons per year.

15 Yidu–Dajiawa: Construction began in May 1984 on this 71 km line, which is scheduled for completion in 1986; salt from Laizhou Bay will be the primary commodity transported.

16 Yuancheng–Danjiazhuang: Double tracking on this 213 km line was recently completed, and capacity raised from 20 to 50 million tons per year.

nijiazhuang–Dezhou: Double
ng of 181 km line has increased
ity from 20 to 50 million tons
ear.
iyuan–Shijiazhuang: Electrifi-
i of this 239 km line in 1982
i capacity from 35 to 50 million
per year. Further work on com-
cations and power facilities
ng this year will raise capacity to
illion tons.
iyuan–Lanxian: Fenhe–
cheng section of this new line is
ly in operation.
nzhou–Baoji: Electrification of
11 km line will be completed in
increasing capacity from 7 to
illion tons per year.

ouma–Yumenkou: New single
79 km line is currently under
uction.
iyuan–Puzhou: Double track-
i this 488 km line began in
and is to be completed by the
980s; capacity will increase
17 to 30 million tons per year.
ouma–Yueshan: Construction
s new 249 km single track line
egin in 1985.
inmenxia–Zhengzhou: Electrifi-
i of this line will begin in 1984–
anced by Japanese loans.
hangzhi–Handan: This new line
ed in 1982 with a capacity of 6
n tons per year; further im-
ments will bring capacity up to
illion tons per year.
hangzhi–Xinxiang: When elec-
l in 1985, capacity will increase
17 to 35 million tons per year.
iozuo–Zhicheng: Capacity of
56 km single track line was re-
y expanded.

28 Zhengzhou–Wuhan: A World Bank loan in 1985-86 will electrify this 540 km line and expand capacity from 35 to 55 million tons per year.

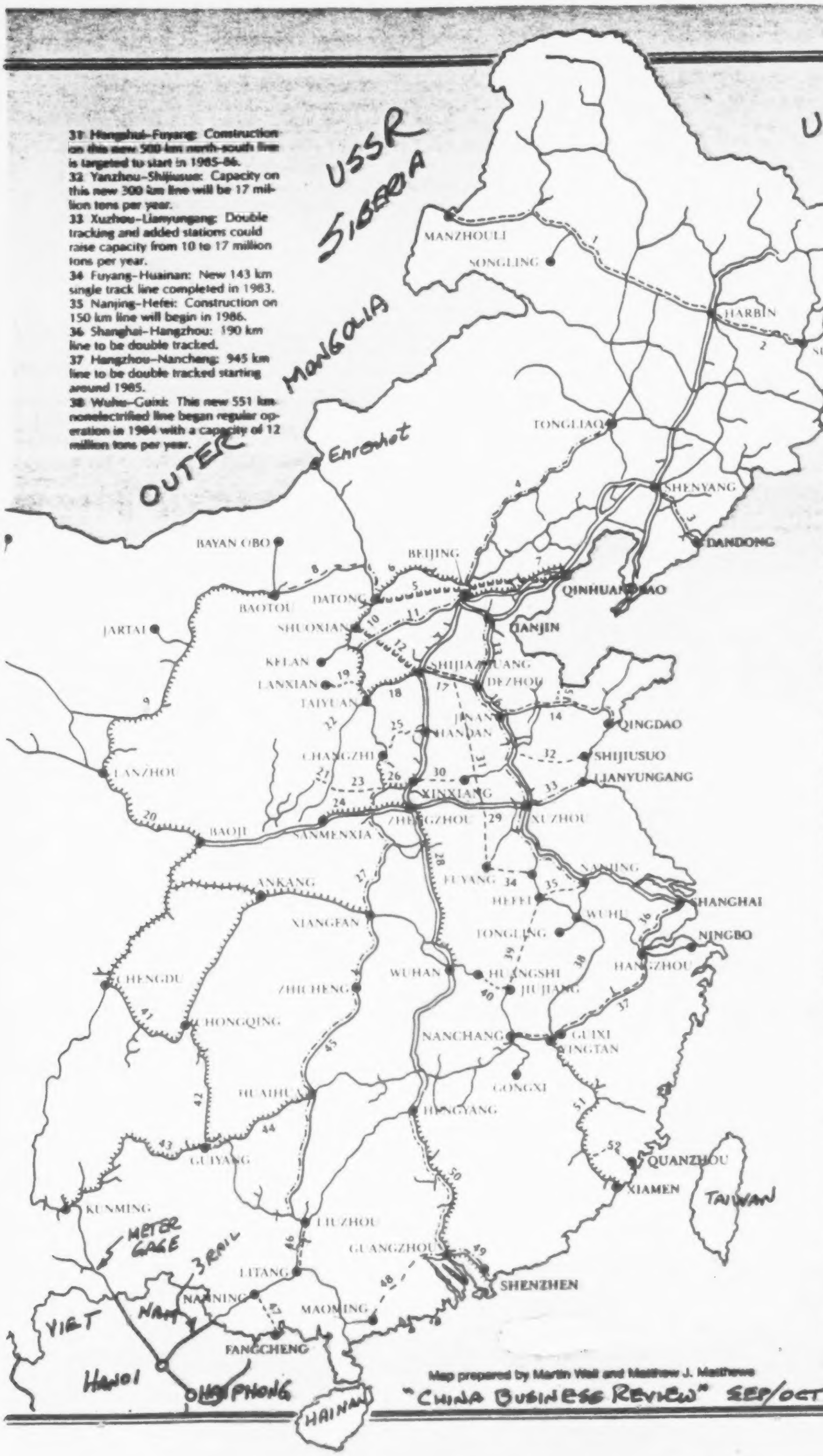
29 Zhengzhou–Xuzhou: Double tracking was completed in 1982, raising capacity to 50 million tons per year.

30 Xinxiang–Yanzhou: The first 164 km section between Xinxiang and Heze is a new single track line with 10 million tons per year capacity; capacity on 140 km second section from Heze to Yanzhou will be expanded to 17 million tons per year.

SIBERIA
KAZAKHSTAN
DZRUBHA (KAZAKH SSR)
ALATOU PASS
USU
53
URUMQI
KORLA
GOLMUD
LHASA
Existing single track
Existing double track
Existing single track to be double tracked
Electrification of existing line
Capacity of existing line to be expanded by means other than double tracking or electrification, such as by installation of heavier track or modern signaling systems
New line, not electrified
New electrified line
Existing electrified line

"CHINA BUSINESS REVIEW" SEPT/OCT 1984

Figure 8. China Business Review" Sept/Oct 1984.


USSR
SIBERIA
USSR
MONGOLIA
OUTER
Ehrenhot
o Vladivostok
MANZHOULI
SONGLING
HARBIN
SUIFENHE
TONGLIAO
SHENYANG
DANDONG
BAYAN OBO
BEIJING
DATONG
BAOTOU
QINHUANGDAO
TIANJIN
JARTAI
SHUOXIAN
KELAN
LANXIAN
SHIJIAZHUANG
DEZHOU
TAIYUAN
JINAN
QINGDAO
HANDAN
CHANGZHI
SHIJIUSUO
LANZHOU
LIANYUNGANG
XINXIANG
BAOJI
SANMENXIA
ZHENGZHOU
XUZHOU
NANJING
FUYANG
HEFEI
SHANGHAI
ANKANG
WUHU
XIANGFAN
TONGLING
NINGBO
HANGZHOU
CHENGDU
WUHAN
HUANGSHI
ZHICHENG
JIUJIANG
CHONGQING
NANCHANG
GUIXI
YINGTAN
GONGXI
HUAIHUA
HENGYANG
GUIYANG
QUANZHOU
XIAMEN
TAIWAN
KUNMING
LIUZHOU
METER GAGE
3 RAIL
GUANGZHOU
LITANG
SHENZHEN
NANNING
MAOMING
VIET NAM
FANGCHENG
HANOI
HAIPHONG
HAINAN

31 Hangshui–Fuyang: Construction on this new 500 km north-south line is targeted to start in 1985-86.
32 Yanzhou–Shijiusuo: Capacity on this new 300 km line will be 17 million tons per year.
33 Xuzhou–Lianyungang: Double tracking and added stations could raise capacity from 10 to 17 million tons per year.
34 Fuyang–Huainan: New 143 km single track line completed in 1983.
35 Nanjing–Hefei: Construction on 150 km line will begin in 1986.
36 Shanghai–Hangzhou: 190 km line to be double tracked.
37 Hangzhou–Nancheng: 945 km line to be double tracked starting around 1985.
38 Wuhu–Guixi: This new 551 km nonelectrified line began regular operation in 1984 with a capacity of 12 million tons per year.

39 Hefei–Jiujiang: Part of new north–south line to be completed by 1990.
40 Daye–Shahecheng: New 128 km line designed for steam locomotives with initial capacity of 7 million tons per year.
41 Chengdu–Chongqing: Electrification of 504 km line should double capacity to perhaps 20 million tons per year when completed in 1986.
42 Chongqing–Guiyang: 463 km line currently being electrified.
43 Guiyang–Kunming: Electrification will begin in 1984 and be completed in 1988-89, raising capacity from 6.9 million to about 22 million tons per year; track weight will increase from 43 kg. to 50 kg., and train weight with one locomotive will increase from 2,250 tons to 3,600 tons with two locomotives.
44 Guiyang–Huaihua: Electrification began this year.
45 Zhicheng–Liuzhou: Current capacity of 7 million tons per year will increase to 15 million tons per year when track and signaling systems are upgraded.
46 Liuzhou–Litang: Currently being double tracked.
47 Nanning–Fangcheng: New 180 km line to be completed in 1986. Initial capacity 10 million tons using diesel locomotives will be expanded to 15 million tons in the future with longer sidings, etc.
48 Sanshui–Maoming: This new line will have a capacity of 10-15 million tons per year and will use 50 kg/meter rail. Completion is targeted for 1986. The Sanshui–Guangzhou section will also be rebuilt.
49 Guangzhou–Shenzhen: New stations will be established and others will be expanded on this 147 km line. With electrification, capacity should rise to about 20 million tons per year.
50 Hengyang–Guangzhou: Electrification and double tracking projected to increase capacity to 30 million tons per year.
51 Yingtan–Xiamen: Current electrification work on this 694 km line will double capacity to 12 million tons per year.
52 Changping–Quanzhou: 194 km new single track line under construction. Will use steam locomotives, initial capacity 5 million tons per year, may be expanded later to 8 million tons per year.
53 Urumqi–Usu: New line.

Artwork by John Yanson

Map prepared by Martin Weil and Matthew J. Matthews

"CHINA BUSINESS REVIEW" SEP/OCT 1984.

Figure 9. "China Business Review" Sept/Oct 1984

2. ELECTRIC LOCOMOTIVES

Alsthom MTE of France received an approximate $US270 million value order for 150, 6,400 kw (8600 input HP) two unit electric locomotives with four powered axles under each unit in two trucks ("Bogies" in European parlance). These can operate with two locomotives in multiple unit under the control of one engineman. In this case there would be 16 powered axles and total electrical input HP of 17,200. Tractive HP available at the rail (input less auxiliaries and typical efficiency) would be about 15,500 THP.

Alsthom will assist PRC in setting up facilities to produce this type of 25,000 volt single phase AC locomotive in China.

Previously Alsthom has enjoyed considerable business with PRC beginning in the late 1950's. This included:

10 Co-Co (six wheel trucks all axles powered) 4,400 kw (6000-HP) electric locomotives in 1960. These had US WABCO type 14-EL brake equipment and French WABCO air compressors.

40 Co-Co 5,400 kw (7300 HP) electric locomotives in 1970-73. These 40 electrics had US WABCO modern type 26-L brake equipment supplied and slightly modified by French WABCO.

50 Co-Co 2980 kw (4,000 HP) diesel electric locomotives in the 1971-1974 period. These also had US WABCO type 26-L brake equipment.

Alsthom has also supplied equipment for the French Consortium which erected and showed PRC "how to do" the 50 HZ 25,000 volt single phase AC catenary and power distribution system.

3. FREIGHT CARS

a. Automatic Bottom Dump Pullman Hoppers

Pullman Technologies Inc. received an order from the PRC Coal and Mining Ministry for a "70-ton" version of their T-16, 100 US ton capacity automatic bottom dump door unit coal train car. This car design has a 15 years of successful service in USA, and PRC engineers have observed the unloading operations, where coal is dumped into a large pit at whatever location is desired by the pit operator. Coal from the pit is distributed by conveyor belts to stock piles or to direct ship loading belts. This fast unloading and loading of cars in a complete train is of much interest to China's Coal Ministry to improve their throughput. Fifty of the Pullman Technologies T-12 design are under construction by China's Heavy Machinery Corporation. They will have service trial and testing as a single unit train on new pit/conveyor unloading facilities. Pullman expects that a large number of additional cars of type will be built by China. Pullman receives a royalty for each car built.

The T-12 car has a second trainlined pipe for charging the air dump reservoirs with main reservoir (MR) pressure from the locomotives as the unloading pit is approached. When the dump valve is moved to "open" (either automatically or manually) a large air cylinder operates the door linkage to open all the doors. After unloading another mechanism actuates the dump valve to operate the air cylinder to close and lock all doors. The first 50 cars being built are being equipped with PRC's present standard GK triple valve automatic air brake equipment with a manual empty/load feature. The GK is similar to AAR former standard K-2 triple valve equipment but suitable for a 14" dia. brake cylinder.

Because of the long 100 to 150 car trains in North America, the AAR AB type freight brake was developed and applied to virtually all cars during the 1933-1960 period. Present PRC freight trains are in the 50 to 65 car maximum range although all new coal lines have sidings long enough for 120-130 car trains. Upgraded main lines will gradually be changed over to passing tracks which can accommodate 80 then 100 then 120 car trains.

b. P & LE 70 Ton Hoppers

The China National Machinery Import and Export Company, purchased 200 AAR, 70 ton capacity triple hopper coal cars, from the Pittsburgh and Lake Erie Railroad. The Ministry of Coal and Mining wish to experiment with hopper bottom unloading coal cars to see if this common US design can be practically used in China for some unit coal train services. The hopper bottom car design is a much stronger, shorter, and more economical car for carrying bulk ladings such as coal, rock, sand, gravel, than PRC's present design, solid bottom, high side gondola, with 3 to 5 gated doors on each side. The high side gondola with side doors is common in Europe, and is the workhorse and the largest group of cars in PRC's 350,000 freight car fleet. A hopper car requires a raised open trestle or a pit under the track for practical use. The P & LE Hopper cars were built by Bethlehem

Steel Car Co. in 1956-57 and rebuilt in P & LE's McKees Rocks Shops 1970-73. These cars are of plain carbon steel, weigh 51,000-lbs empty, and have an AAR gross rail load of 220,000 lbs. Thus their load limit is approximately 170,000 lbs or 85 tons (77 metric tonnes). Cubic capacity is 2500 ft^3 (70.8 m^3). In the rebuilding, all were converted to 6" x 11" roller bearings. Cars are equipped with AB brake control valves with brake cylinder release valves, 10" x 12" AB brake cylinders, conventional brake rigging and cast iron Hi-phosphorus brake shoes. They are equipped with 33" one wear wide flange cast and wrought steel wheels. The Chinese required all wheels to be turned to AAR narrow flange contour before shipment. The PRC standard wheel is very close to AAR narrow flange contour. PRC also lays track to "tight gage."

c. Intermodal Flat Cars

China has not designed, nor built any flat cars primarily suited to carry automobiles, trucks, highway trailers, or international/domestic type containers. Because of technical obsolescence, Trailer Train Company, the world's largest private (non-railroad) freight car owner with over 90,000 cars (1/4 of PRC's total fleet), has a surplus of several thousand, 85 foot long, AAR 70 ton capacity highway trailer (TOFC) flat cars, with 33" wheels and standard floor height. They have offered to sell some of these to PRC railroads. However, China does not have much need for highway truck trailer transport, not having a heavy duty inter-city highway system.

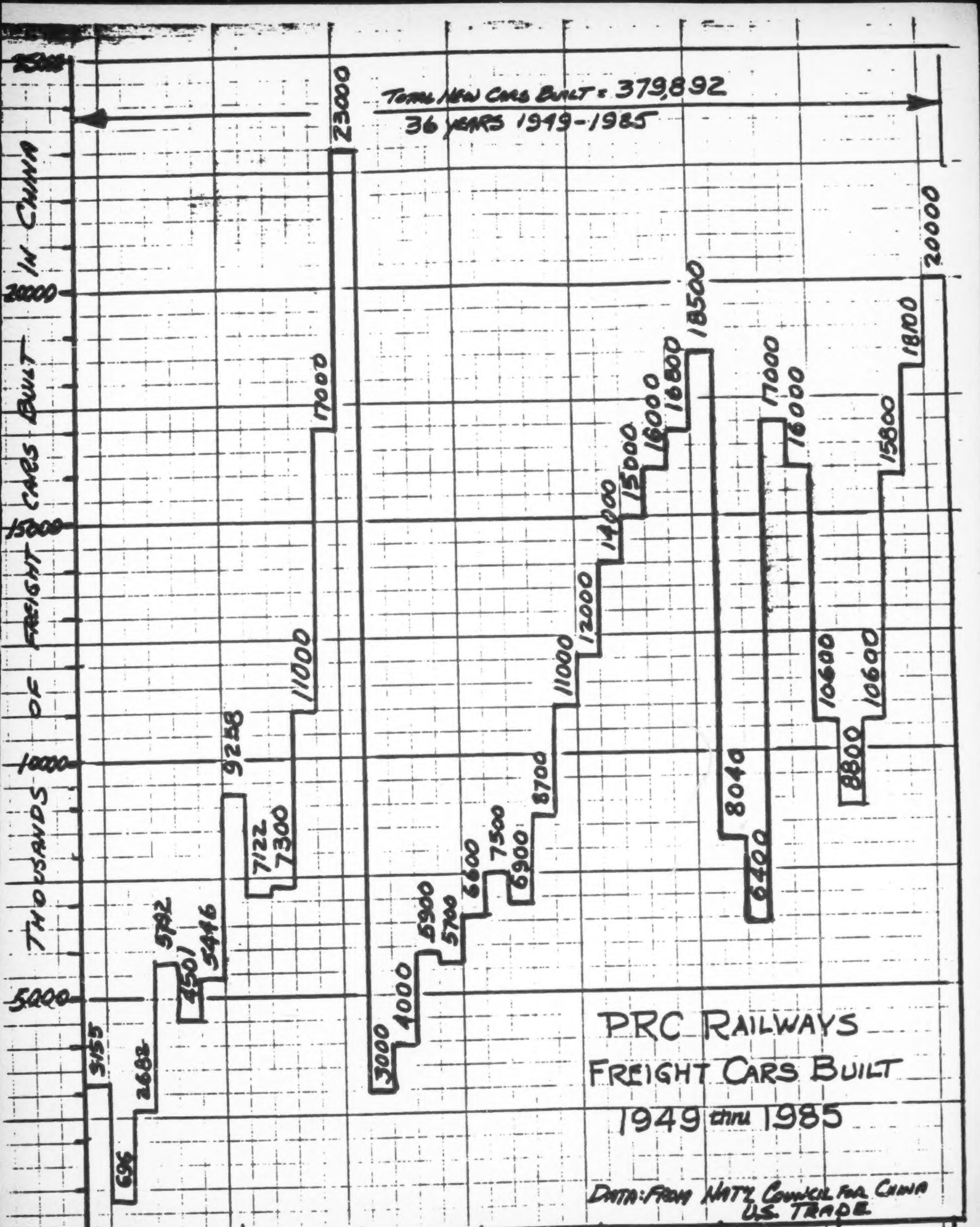
China is, however, beginning to develop inland container routes, and has interest in some of these 85 foot TTC cars converted to handle two, 40 foot international sea or land freight containers. TTC has worked out a means to convert these, and will demonstrate this to a delegation of PRC railway and transport people in the next few months.

d. Box Cars

Trailer Train Company also has several thousand 50 ft, all steel, 70 ton AAR capacity box cars for sale. PRC engineers have said these RBOX cars are too high at the roof eaves for adequate clearance in many of their hundreds of tunnels and also a large number of truss span bridges. A similar clearance problem exists if modern highway trailers are loaded on the standard US floor height TOFC cars. Obviously, China has not worked to the AAR standard plate "C" clearance diagram.

e. Figure 10 shows new freight cars built by PRC since independence in 1949. The approximate total of 379,892 gives an average of 10,552 per year, for the 36 year period. Through the early 1960's the large majority of cars were of 40 and 50 tonne (44 to 55 ton) capacity, and equipped with the Chinese version of our "K-2" type triple valve air brakes.

The 60 tonne (66 ton) capacity freight cars began to be manufactured in the early 1960's, and this size has been their "standard" for the past 20 years. About 280,000, 60 tonne capacity box cars, gondola cars, flat cars, and tank cars have been built. PRC badly needs to improve their refrigerator car



PRC RAILWAYS
FREIGHT CARS BUILT
1949 thru 1985

DATA: FROM NAT'L COUNCIL FOR CHINA U.S. TRADE design, (nominally a 40 tonne capacity, but weighing about as much as a 60 tonner loaded). Their car uses water/ice bunkers as were common in North America until the early 60's. We have changed over to diesel engine mechanical temperature control on each car. Much of our present fresh fruit and vegetable traffic now moves piggyback in mechanically refrigerated highway trailers.

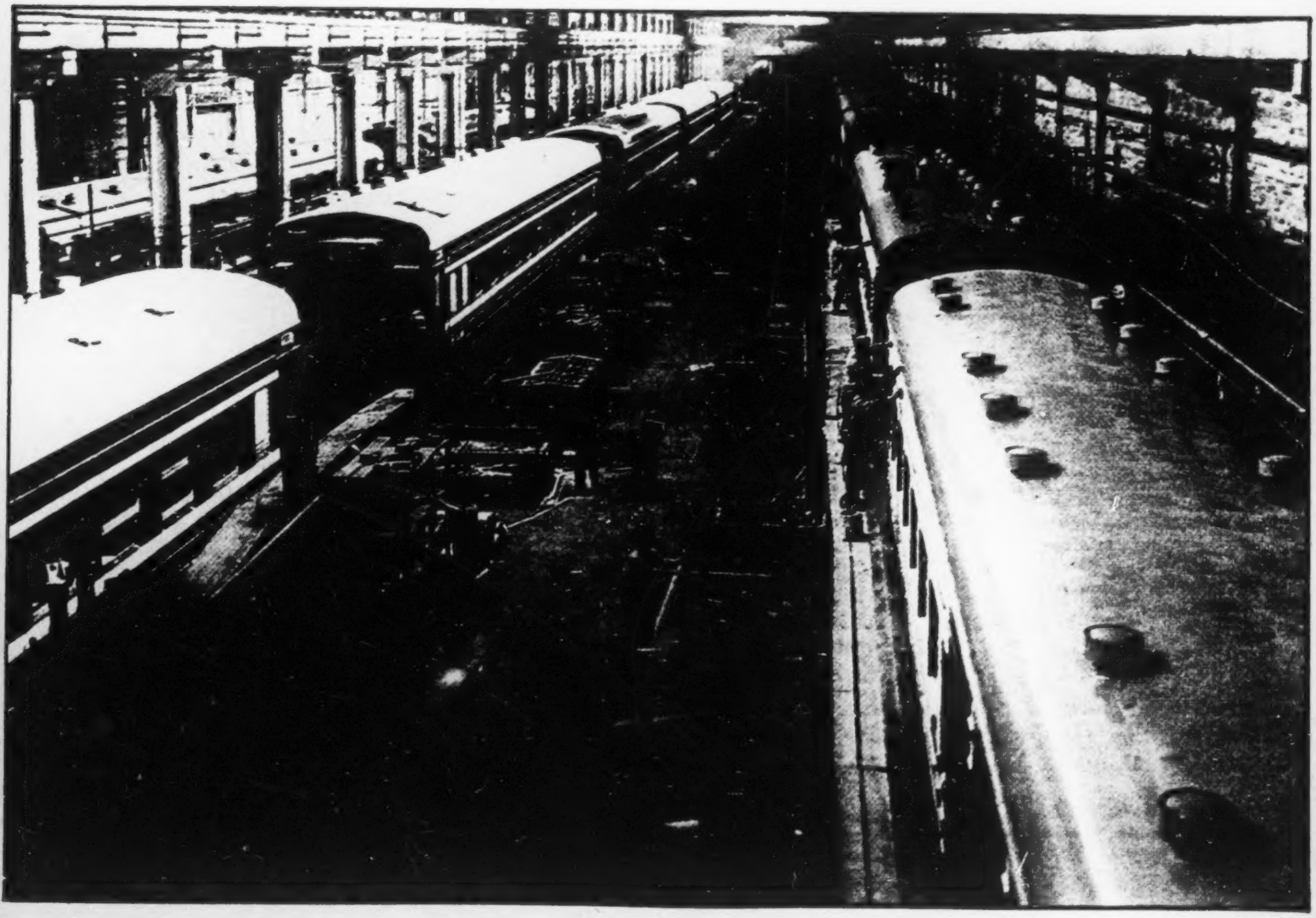


Figure 10.

f. Prototype PRC Design Unit Coal Train Cars

The new "70" tonne unit coal train gondola car was designed by the Locomotive and Car Institute of the China Academy of Railway Sciences. These 290 car pilot program cars have an improved PRC cast steel 3 piece truck with 33" wheels and roller bearings. These 290 cars have solid bottoms, but retain 3 side doors for "universal" use in China. Their cubic capacity is 69.4 cubic meters (2449 cubic feet) which is slightly smaller than the 200 P & LE hopper cars they purchased for trial service. The PRC new design car made of low carbon steel, weighs 23 tonnes (50,715-lbs) empty, and normally will be 84 tonnes (185,220) loaded although it is capable of 92 tonnes gross weight. The ABDW with SC-1 empty load brake equipment gives 22.7% net braking ratio empty @ 50 psi, and 11.4% net braking ratio loaded (to 84 tonnes gross) @ 50 psi. COBRA HFC (Railroad Friction Products Co.) composition brake shoes are used with conventional rod, levers type brake rigging. Brake cylinder diameter is 10" and the overall lever ratio is 8.09/1.

The loaded net braking ratio of 11.4% @ 50 psi is higher than the present AAR maximum of 10% @ psi for high friction composition shoes. However, in mountainous heavy grade territory, China uses 6 kg/cm^2 brake pipe pressure (85 psi). In full service this will provide 60 1/2 psi brake cylinder pressure and a resulting 13.8% full service net braking ratio. For good train handling down 2% and 3% grades, and adequate margin to slow down and stop US and Canadian railroads dispatch trains with overall train net braking ratios of 13% to 16% in full service. Emergency is about 20% higher (16% - 19%) and is reserved for extra-ordinary situations, where the train must be stopped in the shortest possible distance. The empty car net braking ratio of 22.7% is less than AAR maximum of 30% @ 50 psi. Their need for higher loaded braking ratio is no doubt related to shorter signal block distances than ours. 1 1/4" brake pipe length from hose coupling to hose coupling is 13 meters (42'-6").

4. BRAKE SYSTEMS FOR FREIGHT AND PASSENGER TRAINS

a. Freight Car Brakes

PRC recognizes the limitations of their GK triple valve which, while adequate for 50-60 car, 3000 ft. long trains is not suitable for trains longer than about 4000 ft. of brake pipe. They are much interested in the modern AAR AB type with ABDW control valves, which regularly handle trains of 2000 to 10,000 feet of brake pipe length. Modern design AAR-ABDW equipment is allowed 16 year cleaning period by the FRA. The GK must be cleaned every couple of years.

China has designed and built 290 new "70" tonne (Sec. 3f) unit coal train cars for which they purchased modest quantities of ABDW air brakes and other items from US companies in 1984.

	160 CAR SETS	130 CAR SETS
ABDW Air Brake Control Valves SC-1 Empty Load Details	Westinghouse Air Brake Div. of Amer. Std. Corp.	New York Air Brake Div. of General Rwy. Signal Corp.
Welded Pipe Fittings	WABD	NYAB
10"x12" ABU Brake cylinders	WABD	NYAB
1 1/4 Ball style angle cocks	WABD	NYAB
Brake Pipe End Hoses	WABCO Dual Lock	NYAB NYCO Lock
Automatic Slack Adjusters	Cardwell Westinghouse	SAB-NIFE Type DRV
AAR Geared Hand Brake ARR-66 Type	Universal (Cardwell West.)	SAB-NIFE AJAX
High Friction Composition Brake Shoes	Railroad Friction Products Co. 2" COBRA Shoes	RR Friction Products Co. 2" COBRA Shoes

Total value of this is approximately $2,600 per car set.

b. Locomotive Brake Systems

As previously mentioned, PRC railways have adopted the North American style of automatic air brakes based on principles laid down by George Westinghouse, and codified by the Master Car Builders Association in 1889 (later Association of American Railroads). Locomotive brake equipments in China derive from AAR/WABCO #6-ET and #14-EL which will control direct release freight car brakes of AAR former standard "K" types, and later AB types as well as passenger cars with "L", "UC", "D-22" or modern "26-C" graduated release type.

The modern compact AAR control panel mounted 26-L locomotive brake can control direct or graduated release car brakes on trains of any length. 26-L has automatic brake pipe pressure maintaining, and self lapping, with handle position directly analogous to the brake pipe pressure being called for and supplied to the train.

26-L was first supplied to China on the 1971-73 Alsthom (France) locomotives, through WABCO, France. With the completion of the 422 GE diesel electrics, PRC will have 512 locomotives with AAR 26-L. 26-L in various forms has been applied to about 30,000 locomotives, world wide. 26-L is uniquely suited to controlling two to four (or more) locomotives operated in multiple unit with full independent (locomotive only) brake control.

The 150 new Alsthom twin unit electrics, will have WABCO France type PBL (push button locomotive) equipment, which is a "control desk mounting" equipment having similar functions as

26-L. It is arranged for electric actuation from either of two control cabs at the ends of a single centrally located train brake pipe pressure control center.

c. Passenger Car Brakes

PRC's present standard passenger car brake system is a Chinese version of our old "L" triple (1907 vintage), which has a graduated release feature, which can be cut-in for short trains or cut-out for long trains. Chinese locomotive enginemen generally use the "two application stop" North American brake manipulation, which does not make use of graduated release, and is uniquely suited to accurate spotting along station platforms.

The Brake Engineering Department of China Academy of Railway Sciences has had a modern diaphragm, "O" ring, Poppet valve construction passenger car control valve, called W-104, under development for some years. Functionally, the W-104 is generally similar to our 26-D type.

China has obtained some UIC (European) type control valves for experiment and trial service. In Europe, the same basic control valve is used for locomotives, passenger and freight cars. Other functions can be added to the basic UIC valve by use of filling pieces: Two stage empty/load; continuous variable load; speed governor control; dynamic or regenerative brake interlock; blended air and dynamic brakes.

PRC has shown little interest in NYAB or WABCO passenger style brakes of the 26 type or the GSX-3 type as on our AMTRAK and Canadian VIA cars.

d. High Friction Composition (HFC) Brake Shoes

PRC is exploring importation of technology to manufacture AAR style high friction composition wheel tread brake shoes. They have contacted the three major US and Canadian manufacturers:

- Railroad Friction Products Co. (WABC, and Johns Monville) who make the "COBRA" shoe.
- Griftin Wheel Co. (Amsted Industries) who make the "Anchor" shoe.
- ABEX Corp. (Formerly American Brake Shoe and Foundry Co.) who make the "Comet" and "Tiger" shoes.

At this writing no decision has yet been made. China has a modest size facility where they have been making limited quantities of both HFC tread and disc brake shoes.

The China academy of railway science designed and built a 250 kw full scale wheel and brake testing dynamometer on which they test and research tread brake shoe, disc and wheel designs.

e. Disc Brake Equipment for Passenger Cars

Using their dynamometer for testing, China has developed a disc brake which they plan to employ on new passenger cars. These discs have ventilating ribs and are similar to the North American WABCO (Formerly BUDD) designs. Discs can be bolted to an axle hub mounting or bolted to the wheel hub. Thus China has shown little current interest in US or European disc designs.

5. CAR AND LOCOMOTIVE COMPONENTS

a. Couplers and Draft Gears

China is much interested in our designs of rotary and non-rotary AAR "F" style interlocking couplers for use on unit coal train cars. They have purchased a few hundred car sets from both Amsted International (American Steel Foundries) and National Castings Inc.

PRC has taken proposals for technology transfer and manufacturing know how from these companies which also includes the standard AAR type "E" coupler. No decision has yet been made.

Their present coupler, called their type #13, is similar to the older AAR type "D" but uses a vertical rather than a horizontal draft gear key attachment in the coupler yoke.

One hundred car sets of American Steel Foundries rotary interlocking AAR type "F" couplers have been sold to China through Amsted International (Amsted is the parent company of America Steel Foundries).

China has been discussing a licensing agreement with Amsted International agreement with Amsted International to set up manufacturing facilities to produce American Steel Foundries basic AAR type E couplers and type "F" interlocking rotary couplers. PRC is aware of American Steel Foundries cast steel brake beam but has not as yet shown interest in this item.

The modern basic AAR friction draft gears (shock and impact absorption) attached to each car coupler are of high interest to the Chinese. Their present designs are similar to the Miner

Enterprises Inc. models of the late 1940's and early 1950's. Several hundred car sets have been purchased from both Miner Enterprises and Cardwell Westinghouse (Mark 50 type). China will try these in service which includes the 290 new PRC design rotary dump 70 tonne (77 ton) cars. Ultimately PRC will decide which technology to import.

All 422 GE Diesel Electric Locomotives are equipped with National Castings Inc. locomotive couplers and draft gears with an approximate value of $US800,000.

Also, of interest, National Castings originated the "Willison" style (semi-interlocking automatic style) coupler which is favored by Soviet Russia. The Willison requires an adaptor to couple with the AAR type E or F knuckle style couplers.

In this connection it is interesting that the two daily Beijing to Moscow passenger trains use AAR style knuckle couplers, which Russia accommodates.

b. Freight Car Trucks

The PRC Academy of Railway Sciences also has designed and made their own improved version of their "stabilized" cast steel freight car truck for their new "70" ton unit coal train cars. They have used truck designs which appear very similar to American Steel Foundries' "Vulcan" export truck of the late 1930's and early 1940's. This is a plain journal bearing style with Journal Box Covers which bolt on securely to discourage pilfering of the large brass bearings. The size is between the

AAR 50 ton (5 1/2"x10" - 140x255mm bearings) and 70 ton (6"x11" - 152x280mm bearings). These trucks have a variable friction snubbing feature similar to Standard Car Truck Company's "Barber" design copied by Soviet Russia many years ago.

National Castings Inc. has a full line of AAR approved cast steel freight car trucks, some with their own "wedgelock" style of friction snubbing.

c. Axles and Bearings

China forges and machines her own car and locomotive axles. These are made to accepted general standards used on both AAR and UIC railroads. In China all passenger cars, electric and diesel electric locomotives use roller bearings which are manufactured in China. Designs appear similar to those used in Russia which show strong resemblance to SKF.

China's freight car fleet is equipped with journal bearing brasses and they employ a form of journal bearing stops plus a lubricator pad which rests in the oil reservoir of the bearing box and contacts the lower art of the machined and burnished axle journal bearing. Very few roller bearings have been applied to freight cars.

The GE diesel electric locomotives have Timken bearings. PRC has shown some interest in upgrading their roller bearing manufacturing facilities although it is suspected they would probably follow SKF rather than Timken technology.

One advantage in purchasing the 200 P & LE Hopper cars was to get service experience with a number of makes of US AAR approved, freight car style, "AP" bearings, such as SKF, HYATT, TIMKEN, and BRENCO. The AP style was originated by Timken, and PRC has had access to this design through open communications with British Timken Ltd.

d. PRC Steel Wheels

China uses the wrought steel (forged and rolled steel) wheel for its freight and passenger car wheels and steel tires which are used for locomotive wheels. The wheel rims are thick and similar to our multiple wear design. Tires are locked to locomotive wheel centers with a method similar to European UIC design. Contour of wheel flange and tread is similar to the AAR narrow flange or UIC standard wheels. The carbon content of wheels and tires is approximately 0.62% which is similar to AAR class B heat treated wheels.

PRC is interested in improving their quality of Ma An Shan, Anhui province wheel plant products. The Ministry of Metallurgical Industries visited several US wheel manufacturers. China invited an expert, a retired Bethlehem Steel Co. wheel and rail engineering manager to spend some weeks in China assisting them in analyzing and planning quality improvements.

PRC teams visited Griffin Wheel Company's new Keokuk, Iowa Cast Steel Wheel Plant. While they found the ASF's (parent company of Griffin) pressure pouring method innovative and interesting, PRC railways felt they were locked in to improvement to their existing wrought steel wheel process because of Ministry of Metallurgical Industries directives.

6. PASSENGER CARS

China's lack of passenger carrying capacity, particularly on the main, very heavy traffic, north-south and coastal corridors, is of great concern to PRC railways. Present 13 to 16 car trains stopping at all major cities are seriously overloaded. Temporary relief is being obtained by virtually doubling the length of trains to 25-32 cars. These double length passenger trains operate on a "skip-stop" basis (such as "A" and "B" transit trains), but they require two separate stops and more than twice the present time at station platforms.

Thus, present overall total train movement per day cannot be improved because of much longer station dwell times. China is now reviving their interest in double deck passenger coaches which can carry from 60% to 80% more seated people than present 25 meter long (83-ft) single level cars.

The PRC railway people have contacted and explored various car builders in Europe and Japan, plus at least two in USA: Pullman Technologies Inc. and Transit America (formerly the BUDD Company Rail Car Division). Pullman has built over 500 Bi-level passenger cars since the 1950's for inter-city and long distance suburban services.

The Bi-level cars seat 160 vs approximately 90-105 on older single deckers. Pullman has also constructed 275 high level passenger coaches, diners and sleepers for long distance inter-city service. Coaches seat 88 vs 56. Pullman's Amtrak designs are basically low alloy carbon steel and/or aluminum. Transit America's designs are stainless steel using a unique "shot weld" process originated by the BUDD Co. BUDD has built several hundred gallery or two level suburban cars, and originated the "high level" mainline cars on the Santa Fe "El Capitan" 33 years ago.

China has very little manufacturing capacity to make stainless steel. However, PRC is interested enough to have ordered three prototype experimental carbodies in stainless steel from Japanese railroad car builders. No decision as to license of designs or joint ventures has been made.

On transit and suburban car orders in the past 5 years, Japanese and European builders have underbid North American (US and Canadian) builders by considerable margins. Apparently these prices were not low enough to qualify as "dumping".

US car builder engineers visiting China report Changchun passenger car building plant appeared fairly modern and well organized. Its present capacity is 700 or so welded steel passenger cars a year. It is suspected that the $US235 million World Bank loan would be for re-equipping and expanding Changchun works to make 1000 double deckers a year. Presumably, Changchun would be free to bid on the open export market.

Companies capable of building Bi-level, high level and double deck design cars are:

Pullman Technologies, Chicago
Transit America, Philadelphia
Hawker Siddeley, Canada
Bombardier, Canada and USA

France, Germany, Italy, Yugoslavia, and Japan also have designed and built "double deck" designs. South Korea, a dark horse until recently, certainly has this capability and a very favorable labor rate and labor cost content in their pricing compared to USA and Canada.

7. SIGNALLING, INTERLOCKING, C.T.C AND TRAIN COMMUNICATION

a. For several decades, China has built up her own capability to manufacture cab signals and automatic train control using coded track circuits very similar to types in common use in US and Canada, in the 1940's and 1950's. The vital (fail safe) signal relays in signal and automatic train control systems are of high caliber, electro-mechanical design. Some resemble Russian styles, but most are apparently based on USA's General Railway Signal and Union Switch and Signal long proven designs.

China's Railway Signal Manufacturing Co. plants also produce remote control board systems for route interlocking, large complicated station track arrangements, and a limited form of centralized traffic control which appears similar to that common in US and Canada, in the 1930 and 1940 period. These are based on hard wire, fail safe circuitry, and electro-mechanical relays.

The PRC plants producing signal equipment also make telephone central station equipment, not only for railroad, but also for general telephonic use.

b. General Railway Signal Co. is starting up the first PRC-USA joint venture company in which they invested $US2.5 million, and the China Signal Manufacturing Co., put in a like amount. The prime purpose is to improve quality, reliability and performance of existing products, and to introduce GRS up to date solid circuit, vital (fail safe) solid state circuitry to all manner of existing and developing new products. The joint venture company is called CASCO (China American Signal Co.) and is now operating, based near Shanghai in a China Signal Manufacturing Co. plant. GRS gets to name the president and the vice president of manufacturing and quality control. These US citizens and company officers are now in place.

1. Automatic Block Signal Systems

   CASCO will analyze and make necessary changes or introduce GRS designs, methods, and manufacture to improve quality and performance of the color light wayside signal systems, cab signal systems and automatic train control systems now being produced in China.

2. Centralized Traffic Control Systems

   CASCO will analyze and improve CTC system design and performance, so that true North American AAR style control over all signals and switches can be practically obtained over several hundred miles of route in PRC. It is expected that major introduction of vital solid state circuitry from GRS will make this practical within a few years.

3. Classification Yard Systems

CASCO will undertake redesign of hump yards and their controls to provide the throughput attainable in North American yards. Switch machines of rugged simplified reliable designs will be provided based on GRS N.A. practice.

4. Retarders

Manually controlled retarders in hump classification yards will be replaced with modern automatic solid state electronic control. This will include state of the art North American technology for preparing "switch lists" from incomming freight trains and outbound destinations. Inert retarder designs at tangent points of classification tracks of proven N.A. GRS design will be provided through CASCO.

5. Highway Crossing Protection

GRS has a long history of development and participation in train approach automatically actuated crossing gates and warning lights. While PRC has relatively little need for sophisticated crossing protection equipment to replace their manual gates and gatemen swinging warning lights, they can well use modern equipment in a number of cities.

B. TRACK AND ROADBED

a. Rail

1. The majority of China's main line routes are laid with 45 to 50 kg/m (90 to 100-lb/yard) rails. This is suitable for 40 and 50 ton AAR capacity cars, with gross loaded weights of 143,000-lb to 177,000-lb (65 to 80 metric tonnes) and locomotives with 46,000 to 50,000-lb axle loads (21 to 23 metric tonnes).

2. Heavier rail sections are needed for AAR 70 ton capacity cars having gross loaded weights of 220,000-lb (100 tonnes). We would use at least 121-lb/yard (60 kg/m) rail. For AAR 100 ton capacity cars of 263,000-lb gross (119.3 tonnes) we would use 132 to 136-lb/yard rail (65.6-67.6 kg/m). China has very limited capability to produce 65-70 kg/m rail but is gearing up for 60 kg/m (121 lb/yd) rail for new coal routes, and very high annual gross tonnage tracks carrying 40 to 60 million gross tonnes (44 to 66 million tons).

3. Considering the labor and total production cost differences between USA and China, it is unlikely they would purchase any significant quantity of our rails.

b. Ties

1. China has very few stands of good oak and other hardwoods from which they can obtain ties. They use

pressure/vacuum treated soft wood ties which only have about 2/3 the life of our similarly treated Red Oak ties in dry climates.

2. PRC engineers indicate that their future lies in prestressed concrete ties. The AAR Chicago Technical Center has run tests for the PRC using their designs of concrete ties to get a comparison of how they might perform under our much heavier wheel and axle loadings.

3. The AAR's Pueblo Test Center is running tests for the PRC on our FAST track to see how their present and their heavier rails and ties react to our 100 ton capacity loaded car trains. FAST test facility can accumulate about a million gross tons per day.

c. Roadbed Structure

PRC Civil Engineers have worked at AAR Research and Test facilities at Chicago, and Pueblo studying our methods of ballast, ballast Fouling Protection, and subgrade construction, including engineering and standards. They have also devised and participated in laboratory and road service test projects. Our use of geotextiles to prevent subgrade mud from working up into the ballast was of much interest to them.

d. In the future we would expect AAR to be doing some of this work on a contract basis for PRC.